OIL, GAS & PETROCHEMICAL PROCESSING

Petroleum Refiner

JUNE
1958

$ $ $ $ $ $ $ $ $ $ $ $ $ $ $

SPECIAL REPORT ON COSTS

What Affects Estimate Accuracy 128
How to Save Money on Exchangers 135
Where Computers Help Economics 151
Reducing Risks in New Ventures 164

$ $ $ $ $ $ $ $ $ $ $ $ $ $ $

NEW INSIGHT

Why Starting Air Lines Explode 171

FUTURE PROFITS

How to Prevent Motor Maintenance 183

MANAGEMENT GUIDE

Communications Can Be Improved 239

For a "Quick Look" at this issue, turn the page . . .

SUBSCRIPTION PRICE $2 PER YEAR
SINGLE COPY PRICE 50 CENTS

The Yarway Impulse started a new era in steam trapping...

. . . it began in 1935, when Yarway applied a unique principle of thermodynamics to steam traps—and the Yarway IMPULSE Steam Trap was born.

Since then over 1,225,000 Yarway IMPULSE traps have proved themselves so well in service that today many other type traps are regarded as obsolete—an understandable reason why the Yarway IMPULSE type of steam trap is being imitated.

To industry, the Yarway IMPULSE trap makes possible a new high in thermal efficiency of equipment, a new low in trap operating maintenance . . . resulting in increased production and higher profits.

THE THERMODYNAMIC PRINCIPLE

This is the principle on which the Yarway IMPULSE trap design is based—that variations in temperature of water discharging through two orifices in series cause variations in pressure in an intermediate chamber between the orifices, and that these changes in pressure may be utilized to open and close the trap valve.

ONE MOVING PART

There is only one moving part in a Yarway IMPULSE trap—a small, stainless steel valve. The entire valve assembly can be replaced in 5 or 6 minutes. It is the simplest of all steam traps to service.

EQUIPMENT HOTTER, SOONER—STAYS HOT

At "start up" the little valve opens wide to discharge air and condensate continuously. This brings equipment into production in the quickest possible time. The valve then actually floats on the condensate load, maintaining highest, steady temperatures.

A YARWAY IMPULSE STEAM TRAP TO MEET EACH TRAPPING REQUIREMENT

Research and development in the Yarway Steam Laboratory, plus intensive field testing, have produced a line of steam traps—*all* of the Yarway IMPULSE type . . . to efficiently meet each of the following classes of trapping service:

Normal requirements for pressures up to 600 psi call for Yarway Series 60 and 120 IMPULSE Traps in six sizes, ½" to 2".

Light loads for pressures up to 600 psi call for the ½" Yarway No. 20-A and No. 120-A IMPULSE Traps.

Heavy loads for pressures to 600 psi call for the extra high capacity Series 40 Yarway IMPULSE Trap, available in five sizes, ½" to 2½".

Highest pressure and marine requirements up to 2500 psi are met by the Yarway Integral-Strainer IMPULSE Trap, in six sizes, ½" to 2", flanged, screwed and socket weld types.

PLUS ADVANTAGES

- Small size and light weight
- Easy, low cost installation
- Minimum maintenance
- Non-freezing
- Stainless steel construction
- No adjustment of valve or seat needed for any pressure
- Low initial cost

NATIONALLY STOCKED, SOLD AND SERVICED

Over 270 Industrial Distributors stock and sell Yarway IMPULSE Steam Traps . . . and over 35 Yarway field engineers are available to help you select the right steam trap for the job.

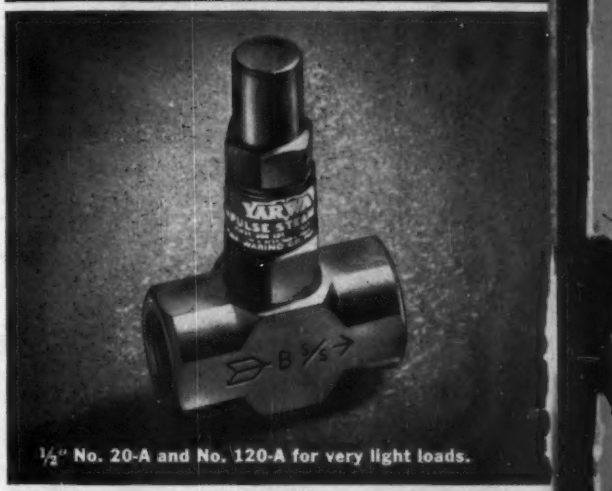
Write for free, new bulletin *"The Why and How of Steam Trapping."*

YARNALL-WARING COMPANY
128 Mermaid Avenue, Philadelphia 18, Pa.

YARWAY impulse®

...a good way to specify steam traps

Series 60 and 120 for normal requirements.



½" No. 20-A and No. 120-A for very light loads.

Series 40 for very heavy loads.

Integral Strainer Impulse Traps for highest pressures and marine use.

Volume 37, No. 6 June, 1958

SPECIAL REPORT ON COSTS

Foreword 127
What Affects Estimate Accuracy? 128
J. W. Hackney
How To Save Money On Exchangers 135
D. Q. Kern
How To Improve Estimate Accuracy 142
W. L. Gore
How To Apply Process Evaluation From Lab To Plant 146
R. L. Buchanan
How Computers Aid Economic Studies 151
H. E. Jones and E. W. Kjellmark
These Factors Affect Project Success 164
Jack Tielrooy

OTHER TECHNICAL FEATURES

The Mechanism of Explosions in Starting Air Lines 171
Robert S. Ridgway
Data Logger Tested in Pilot Work 175
J. J. Arendt and John Savoy
Short Cut To Circular Cantilever Design 179
H. D. Tabakman
PM Cuts Motor Maintenance Costs 183
J. W. Samselius and R. F. Woll
A New Approach to NPSH 191
Lloyd T. Hendrix
Applied Hydrocarbon Thermodynamics (Part 6) 195
Wayne C. Edmister
These Variables Affect Oxo Reactions 209
I. Kirshenbaum and V. L. Hughes
Know Your Asphalts (Part 10) 212
E. I. Barth
Taking Stock 214

As Management Sees It . . .

Communications Can Be Improved—Here's How! 239
Howard E. Turner
Rate Yourself as a Conference Leader 244
Dr. Robley D. Stevens
Start Planning Those Tax Deductions 252
Paul Lockwood

DEPARTMENTS

LOOK BOX. Featuring . . .
The Case of an Engineer "Shortage" 121

Quick Look at Industry .. 9
Mail Box 118
Valuable Reading Ahead 216
How To Do It 218
Who's Building 225
If Oil Could Speak 260
What's Happening 263
Meetings Calendar 280
Men In Industry 282
Suppliers Notes 304
Reviewing New Books .. 319
Classified Advertising .. 322
New Equipment 324
Manufacturers Literature 324
Index to Advertisers 334
Readers Service Card 335

PETROLEUM REFINER, published on the 12th of each month, entered as second class matter June 16, 1923, at the post office at Houston, Texas, under act of March 3, 1879.

Petroleum Refiner
OIL, GAS AND PETROCHEMICAL PROCESSING

A Quick Look at This Issue

These handy digests permit checking the articles you want to read first. ☑

SPECIAL REPORT ON COSTS

☐ **What Affects Estimate Accuracy? . . .** The items that affect estimate accuracy are discussed. Several methods of estimating, with the requirements and limitations of each are described. These pointers as well as the account subdivision will help you evaluate your cost records and estimations methods. Turn to Page 128.

☐ **How to Save Money on Exchangers . . .** Look carefully at company traditions and hand-me-down rules in exchanger specifications. While this is not a set of rules, some very provocative points are discussed. Don't waste money on over surface, excessive fouling factors or expensive methods of construction. Get more exchanger for less money. Turn to Page 135.

☐ **How to Improve Estimate Accuracy . . .** The accuracy and reliability of an estimate can be greatly improved if the uncertainties in each component part are evaluated. Many times proper knowledge of uncertainties can make a high-spot estimate do the job. The use of uncertainties in estimating is explained and there's also a good example. Save yourself some work, turn to Page 142.

☐ **Process Evaluation from Lab to Plant . . .** Today's competitive picture does not permit false starts. To insure success for each new venture, the best chemical, engineering, and economic skills must be applied. Here's a step-by-step example of the application of process evaluation to a synthetic problem. To see what this tool can do for you and your company, turn to Page 146.

☐ **How Computers Aid Economic Studies . . .** This method of determining effects of variables on a proposed project can save both time and money. The computer is only limited by the program and

Please Turn Page ➡

WASTE HEAT FROM STACKS LIKE THESE

COULD PAY 1/5 OF YOUR FUEL BILL

A Ljungstrom® air preheater can cut 20% off your fuel bill by getting more heat from your fuel. That means you burn less of your regular fuel to get the same operating temperature, or you can switch to cheaper fuels without affecting product quality. Either way, every barrel of output can cost 20% less in fuel.

A Ljungstrom air preheater gets more productive heat from any fuel by boosting the temperature of the combustion air – sometimes as much as 1000F. Fuel burns more completely in preheated combustion air, and leaves less slag and deposit behind, so the fuel-burning equipment stays efficient longer.

How fast is "WRITE OFF"?

What you save on fuel can pay for the Ljungstrom in two years. If you take advantage of the extra capacity of a Ljungstrom-equipped system to increase output or to improve product quality, the Ljungstrom can pay for itself within nine months.

Write today for your copy of a factual article by Mr. O. F. Campbell of Sinclair Refining Company, describing one company's fuel savings with a Ljungstrom air preheater. Call or write The Air Preheater Corporation.

Wherever You Burn Fuel, You Need Ljungstrom

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.

human assumptions. The steps outlined here quickly show how you can apply the method in your economic studies. If you are anticipating computer applications, this is must reading. Turn to **Page 151.**

☐ **These Factors Affect Project Success . . .** Successful projects aren't started without considerable study. Many of the factors which can reduce the risk of new ventures should be given careful study. Engineers are obligated to management to supply the answers to all these risk factors. They are all discussed in detail, when you turn to **Page 164.**

☐ **The Mechanism of Explosions in Starting Air Lines . . .** This is a hot one. A close look at operating and research experiences shows great promise for fire resistant lubricants as one way to stop explosions in starting air line on internal combustion engines. Other hints are also outlined in this article on **Page 171.**

☐ **Data Logger Tested in Pilot Work . . .** Sohio has gained a great deal of experience in the use of automatic data loggers. They use one in their pilot plant work, and this story tells what they think of it. **Page 175.**

☐ **Short Cut To Circular Cantilever Design . . .** What are the deformation and strength characteristics of a circular split ring or curved, circular cantilever loaded normal to the plane of curvature? If this seems complicated, use the author's tables and find a simple solution. For complete details, turn to **Page 179.**

☐ **PM Cuts Motor Maintenance Costs . . .** The preventive maintenance that your motors get today will be the maintenance cost cutter of tomorrow. Here's a complete review of the preventive maintenance required in a well organized motor PM program. For complete details, turn to **Page 183.**

☐ **A New Approach to NPSH . . .** Here's the long sought correlation to make sure that pumps have enough suction head. It's based on recent research by CNGA and has been checked in operation. Turn to **Page 191.**

☐ **Applied Hydrocarbon Thermodynamics (Part 6) . . . Improved Mollier Charts for Hydrocarbons . . .** Are you still using old enthalpy data in your hydrocarbon calculations? If so, you'll want to toss them right out of the window and use these improved data for the individual hydrocarbons. Open your notebook and fill it with these new charts of Edmister's. **Page 195.**

☐ **These Variables Affect Oxo Reactions . . .** Here's a summary of the important process variables that affect oxo reactions. Temperature, partial pressure of the synthesis gas as well as catalyst concentration affect reaction rate, type of product and isomer distribution. To make the most of your oxo production and meet marketing requirements, turn to **Page 209.**

☐ **Know Your Asphalts (Part 10) . . . Road Oils or Cut-Backs . . .** One of the most common uses of asphalts for road construction is in road oils or cutbacks. Here are important data on their manufacture and use. Specifications on three of the six grades for each of the three types of road oils are given. For a quick check on your road oil products, turn to **Page 212.**

☐ **Communications Can Be Improved—Here's How . . .** Engineers provide one of the most important sources of top management personnel. The increasing size of engineering staffs, however, has made it much more difficult for management to maintain the bonds of communication which are necessary. This article outlines what must be done to bring about better engineer-management understanding—the key to personal and company success. Be sure you turn to **Page 239.**

☐ **Rate Yourself As a Conference Leader . . .** Leadership can mean the difference between a fruitful meeting and one which accomplishes absolutely nothing. Here is a checklist which you can use to evaluate and improve your leadership techniques. It's a must for those who plan to conduct a business conference. Turn to **Page 244.**

☐ **Start Planning Those Tax Deductions . . .** Next year the expense accounts of oil executives and employes will be in for closer examination by Internal Revenue men. Here's how you can start planning now in order to avoid trouble and to get maximum deductions later. Turn to **Page 252.**

New CROUSE-HINDS EXPLOSION-PROOF MERCURY VAPOR LIGHTING FIXTURES

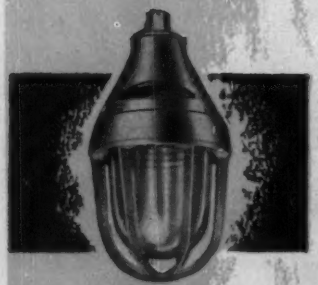
For dependable security at low operating cost in hazardous locations . . .

- *where long burning hours without interruption are involved, month in, month out*
- *where labor cost or trouble of relamping is an important factor*
- *where maximum lighting output calls for maximum economy in power consumption*

The longer life of mercury vapor lamps is well established: 7000 hours, *vs.* 1000 hours for incandescents. Light output is 2.5 times greater; 55 lumens/watt, *vs.* 22 lumens/watt for incandescents.

The new EV's place these economies within easy reach. As with all Crouse-Hinds explosion-proof devices, EV's are heavily constructed to withstand the pressure of internal explosions without rupturing. Gas-tightness is *not* a requirement for their safe performance. Flame-tight joints prevent the escape of flames to flammable atmospheres.

- *For full information, call your Crouse-Hinds distributor, or write for catalog sheet.*



TYPE EVA Explosion-Proof Lighting Fixture

Available with or without guard, or reflector (dome, deep bowl, shallow bowl, angle, or high bay)

250 Watt— National Electrical Code: Class I, Groups C & D

400 Watt— Class I, Group D

CROUSE HINDS

MAIN OFFICE AND FACTORY: SYRACUSE, NEW YORK

Crouse-Hinds Company of Canada, Ltd., Toronto, Ont.

• CONDULET® ELECTRICAL EQUIPMENT (Explosion-Proof and Conventional) • FLOODLIGHTING
• TRAFFIC CONTROL SYSTEMS • AIRPORT LIGHTING and WEATHER MEASURING EQUIPMENT

These products are sold exclusively through electrical distributors. For application engineering help, contact one of the following offices: Baton Rouge, Birmingham, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Corpus Christi, Dallas, Denver, Detroit, Houston, Indianapolis, Kansas City, Los Angeles, Milwaukee, New Orleans, New York, Omaha, Philadelphia, Pittsburgh, Portland, Ore., Salt Lake City, St. Louis, St. Paul, San Francisco, Seattle, Tulsa, Washington. Resident Representatives: Albany, Atlanta, Baltimore, Charlotte, Chattanooga, Jacksonville, Reading, Pa., Richmond, Va., Shreveport

Petroleum Refiner

RAY L. DUDLEY, Founder, 1891-1957

WILLIAM G. DUDLEY.....Publisher
TOM W. NELSON.....General Manager
R. M. DE SOMBRE.....Assistant General Manager
SILAS B. RAGSDALE.....Editorial Director
DR. JOHN J. MCKETTA, JR.....Chairman of Editorial Committee
GEORGE B. GIBBS.....Editor
FRANK L. EVANS, JR.....Maintenance and Design Editor
HAROLD L. HOFFMAN.....Process and Construction Editor
THOMAS C. PONDER.....Petrochemicals Editor
CLAYTON A. UMBACH, JR.....Management and Personnel Editor
HARRISON T. BRUNDAGE.....Eastern Editor
GILBERT M. WILSON.....Western Editor
DR. LEWIS F. HATCH.....Contributing Editor
WALLACE FITZGERALD.....Managing Editor
JACK COCKERHAM.....Presentation Editor
CHARLES VERVALIN.....Editorial Assistant
KATHERYNE BAST.....Editorial Assistant
EUNICE OKONESKI.....Librarian

ADVERTISING

HOUSTON 19: Jack Walker, 3301 Buffalo Drive, Phone JAckson 9-4301; NEW York 17: Gene Hart, George Skelton, 250 Park Ave., Phone YU 6-6558; CLEVELAND 16: Harvey Dunn, Bill Westfall, 20800 Center Ridge Rd., Phone EDison 3-1650; CHICAGO 4: Martin Halloran, H. G. Fitzpatrick, 332 S. Michigan Ave., Phone Wabash 2-9330; LOS ANGELES: Jay Curts, W. W. Wilson Bldg., Huntington Park, Phone LUdlow 7-1219, TULSA 3: Jim Isaacks, 916 Enterprise Bldg., Phone CH 2-9211; DALLAS 2: Ed Thompson, 518 Second Unit Santa Fe Bldg., Phone Riverside 7-7344; EUROPEAN: Theodor Miocke, Agent, Limmerstrasse 31, Hannover, Germany, Phone 42935; UNITED KINGDOM: Frank Chambers, Agent, 120 Moorgate, London E.C.2. Phone Monarch 5661. Advertising rates on application. Cable address: GULFPUBCO, Houston.

SUBSCRIPTIONS

F. G. Spindle, Subscription Manager, P. O. Box 2608, Houston 1, Texas, U.S.A. Single copies 50 cents (except special issues) for domestic and foreign. Double price for copies over one year old. Subscription rates—both foreign and domestic $2 a year. Subscriptions restricted to those engaged in refining, natural gasoline or petrochemical industries or service and supply company personnel connected thereto. Copyright 1958 by the Gulf Publishing Company.

Postmaster: Send notification (Form 3579) regarding undeliverable magazines to Petroleum Refiner, Box 2608, Houston 1, Texas.

Specialized Oil Publications of
THE GULF PUBLISHING COMPANY
Box 2608, Houston (1), Texas

PETROLEUM REFINER and The REFINERY CATALOG for the oil, gas and petrochemical processing industry.

WORLD OIL (formerly The Oil Weekly) and The COMPOSITE CATALOG for the drilling-producing industry.

PIPE LINE INDUSTRY and The PIPE LINE COMPOSITE CATALOG for the oil and gas pipe line industry.

Petroleum Refiner is indexed by Industrial Arts Index, Chemical Abstracts and by Engineering Index, Inc. Microfilm copies available through University Microfilms, Ann Arbor, Michigan.

Fivers on Page 7

THERE HAS BEEN a slight change in PETROLEUM REFINER's front-of-book features as the alert reader might already have noticed. Quick Look at this Issue, Page 5 memos, and Quick Look at the Industry, the features involved, have been changed in position only, the content following their familiar and popular patterns. Quick Look at Industry, that easy-to-read collection of timely capsules which heretofore has appeared just ahead of Look Box, now has been switched to a spot where readers can find it more easily. In getting it on pages 9 and 10, a few other changes, all minor, were made. We hope you'll find the new arrangement to your liking. Only thing that will bother us is that the squibs we used to tag as "Page Fivers" now go on Page 7. And "sevener" sounds a bit gawky.

Repeat X and Y

IF THIS THING keeps up, we think we'll just label some of these squibs "X," "Y," "Z," etc., and instead of re-writing them for succeeding issues just insert a line asking you to "Read X in the May Issue." However, it is important that we hear from our readers on "Who's YOUR Man?," a question we've been asking for several months now. We're talking, of course, about your choice of the man who has made the greatest contribution to the oil, gas and petrochemical processing industry. A card for this nomination is provided opposite Page 334 in this issue. Mail it promptly because we want your thinking when it comes to choosing the 12 or 15 men who will be presented with appropriate description of their accomplishments in our Oil Centennial Issue next January.

For Your Tool Box

WE HAD SEVERAL HUNDRED separates printed of the "Foundation Design for Stacks and Towers" by V. O. Marshall which was featured in our May issue. So let us say here and now before the stack disappears that you'd better get your order in early. It's a real MUST for the design engineer's tool box and recalling the tears that have been shed in past years when we had to turn down orders for this selfsame reprint, we advise buying now. In fact, the recollection of threadbare copies of this article, photostatted and re-photostatted but still being used compels us to suggest you'd better order TWO copies. Address Reprints, Petroleum Refiner, Box 2608, Houston 1, Texas. And inclose $1 for each copy you desire.

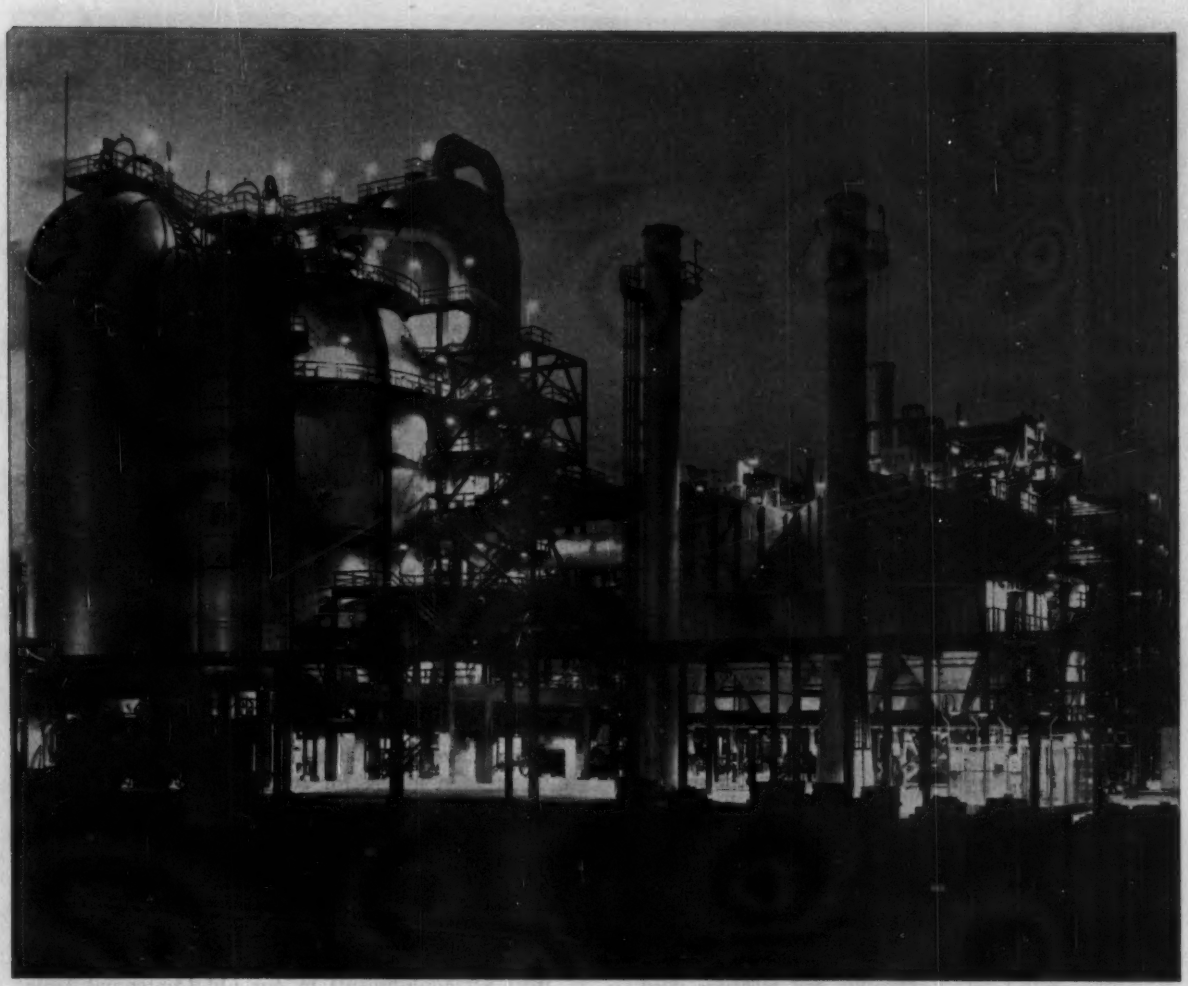
Then, of course, there are these timely and authoritative articles available in reprint form at $1 each:

Perforated Trays by C. J. Huang and J. R. Hodson

Fluid Catalyst Design Data (two parts) by F. A. Zenz

Disaster Planning by Don Lambert

Section II of *Application of Thermodynamics to Hydrocarbon Processing* by Wayne C. Edmister.



Because exceptional resistance to corrosion is needed...

57 miles of Rome Synthinol 901 building wire installed in just one major oil refinery

Under actual working conditions at a major oil refinery in Southern California, Rome's Synthinol 901 outperformed every other building wire tested. The other wires included regular TW, neoprene-covered, and braided rubber-insulated building wires. Lead-covered wire was also tried; and it was entirely satisfactory except for the excessive cost and handling problems.

Rome's Synthinol 901 was used extensively for the low-voltage wiring in this refinery because of its proven resistance to moisture, oil, and corrosive vapors – environmental hazards common to refinery operations. These low-voltage applications – 600 volts and under–include not only control circuits but also the general wiring of office and warehouse buildings and refinery equipment.

Plant and oil refinery engineers have also found that Synthinol 901's superior heat deformation resistance makes it particularly applicable in locations where greater than normal heat conditions exist. In fact, it's now being used in place of Type TA asbestos-covered wire in panel boards and switchboards where high temperatures are known to occur. Rome's Synthinol 901 has proven to be an entirely satisfactory and economical solution to the exacting demands of this type application. Try Rome's Synthinol 901–under your own operating conditions–and see for yourself how well it performs. You'll find it's ideal for low-voltage circuits in refineries, chemical plants, and similar installations where electrical wiring is exposed to corrosive atmospheres.

Specify Rome's Synthinol 901 for your next job. Contact your nearest Rome Cable representative for more information–or write to Dept. 321, Rome Cable Corporation, Rome, N. Y.

ROME CABLE

CORPORATION

A Quick Look at the Industry THIS MONTH

Another Octane Race In The Making? . . . Once more the threat of a costly octane race is looming on the refiner's horizon. Kicked-off with a newspaper ad campaign claiming the highest octane yet, and backed with statements like, "We've waited a long time to take off our gloves in an out-and-out octane race," Tidewater Oil has hurled its challenge at the entire industry.

As a result, refiners are glancing around to see who, if anyone, will accept the challenge. The ensuing battle may mislead the public as to the real value of octanes—to satisfy knock requirements of auto engines. Additional octanes above this are of little value according to some researchers.

One factor which may slow race is expense of still higher octanes. Another is possibility that drivers have heard so much in the past about high octanes and power, they will be no longer impressed.

Actually, the octane picture hasn't changed appreciably in several months. According to Ethyl's survey of octane ratings for U. S. gasolines, premium has remained constant for three months at 98.5 F-1. Last month regular managed to increase by 0.1 for a May average of 91.2 F-1.

More Tracer Work . . . Radioactive carbon now being used to spot main contributions to auto engine deposits. Results show high boiling aromatics to be the worst. Now Esso moves to use gasoline stocks giving high octanes without contributing to deposit nuisance.

For Synthetic Rubber, Troubled Times . . . Drop in new car production has cut into synthetic rubber consumption, but still more trouble looms on European horizon. Last month, for the first time in recent years, natural and synthetic rubber prices were equal. Result: probably some shifting in consumption patterns of each, with synthetic taking a beating.

Another Rubber Market Fizzles . . . Last summer with the advent of air-ride for most '58 autos, rubber companies saw a real sales boom. One company president predicted 1 million cars would have air springs in the 1958 model year. Another went so far as to tool-up one plant to mass produce the rubber diaphragms. However, actual number on 1958 cars will be closer to 100,000. Disappointed GM has put it on only 6 percent, Ford on less than 1 percent, and Chrysler has ignored it.

Import Quota Causing Substitutions . . . American Oil Co.'s new Yorktown refinery is unable to satisfy its crude needs with its import quota. Designed to run Tia Juana crude from Venezuela, plant is operating at reduced capacity on Texas crude and bottoms from topping operations at its Texas City refinery. Meantime, new sulfur plant has gone on stream and is producing about 45 tons of liquid sulfur daily.

Detroit Looking to Fuel Economy . . . Starting with 1959 models, Detroit will stress economy of auto operation. Trend will continue until around 1963 when fuel consumption will have been cut by 20-25 percent of what it is now. Other outlook for '59 models: more chrome, more fins, more gadgets.

Small car sales are still on the up-swing, but probably no major U. S. company

will start building them anytime soon. One spokesman predicted that 100 million economy-size cars with gas turbine engines will be crowding U. S. highways by the year 2000.

Direct Energy Conversion Closer . . . Britain's newest fusion experiment, Zeta Mark II, is aiming for direct conversion of fusion energy into electrical power. Unit is designed to develop temperature as high as 100 million degrees—the break even point between input and output energy levels. If conversion is reached, next step will be to construct prototype fusion power plant aiming at torus current of several million amperes.

Grim Neighbors to the North . . . Import restrictions continue to be major source of irritation between Canada and U. S. Fact that we must have more domestic exploration and development of U. S. reserves to meet possible emergencies is unacceptable to Canadians. They contend we should know that in such an emergency, Canadian crude would be as available as U. S. crude.

Meanwhile, McColl Frontenac Oil spokesmen predicted in Calgary that "well before the year 1966, the U. S. government will have liberalized its petroleum imports policy in order to conserve remaining domestic petroleum resources."

No Wage Patterns Yet . . . No real developments so far in negotiations for wage hikes in oil and chemical industry. IPWA at Indiana-Standard's Whiting refinery settled for a 2 percent increase, difference between the 4 percent they got last year and the 6 percent almost everyone else received.

In Borger, Texas, 4,000 Phillips workers closed installations and walked off their jobs. Wages, however, aren't primary reason for squabble.

In Canada, OCAW claimed a "break-through" in attempt to freeze oil industry wages. Union won settlements from Royalite, Ltd., and Consumers Co-op—got 4.5 percent general increase, shift differentials, and more liberal vacation policy. One unusual benefit: worker who takes vacation in winter gets extra 2½ days' pay.

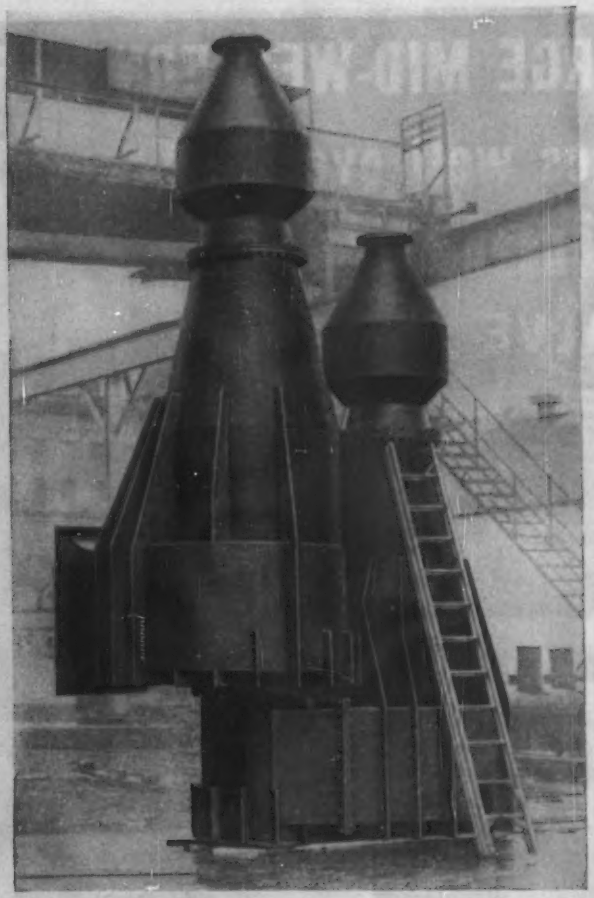
Hancock Refinery Practically Wiped Out . . . Terrific explosion and resulting fires almost wiped out Hancock Oil's Signal Hill, Calif., refinery and gasoline cracking plant. Company's competitors have agreed to refine Hancock's crude to specifications until plant is rebuilt in about six months.

A Quick Look Around the Country . . . U. S. Chamber of Commerce has endorsed voluntary imports plan . . . **Canada's research council at Alberta** predicted first billion barrels of athabasca tar sands will soon enter crude oil market with the second billion barrels following closely . . . **No action this year** for depletion allowance on oil shale by Congress . . . **Federal grand jury** in Alexandria, Va., has indicted 29 oil companies on charges of fixing gasoline and crude oil prices.

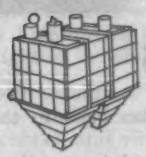
Thin, But Oh So Tough . . . Styrene-acrylonitrile polymer, used as raw material of the newest tableware, produces dishes that are thin as china but practically unbreakable.

Latest Trend Is to Leasing . . . Petroleum refiners are among the top 10 industries who lease the most industrial equipment. According to recent survey, chemical, petroleum and rubber companies are leasing complete contact acid units, cracking plants, research and development plants, and power installations.

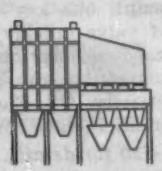
Exploring new frontiers!



BUELL CYCLONES



"SF" ELECTRIC PRECIPITATORS



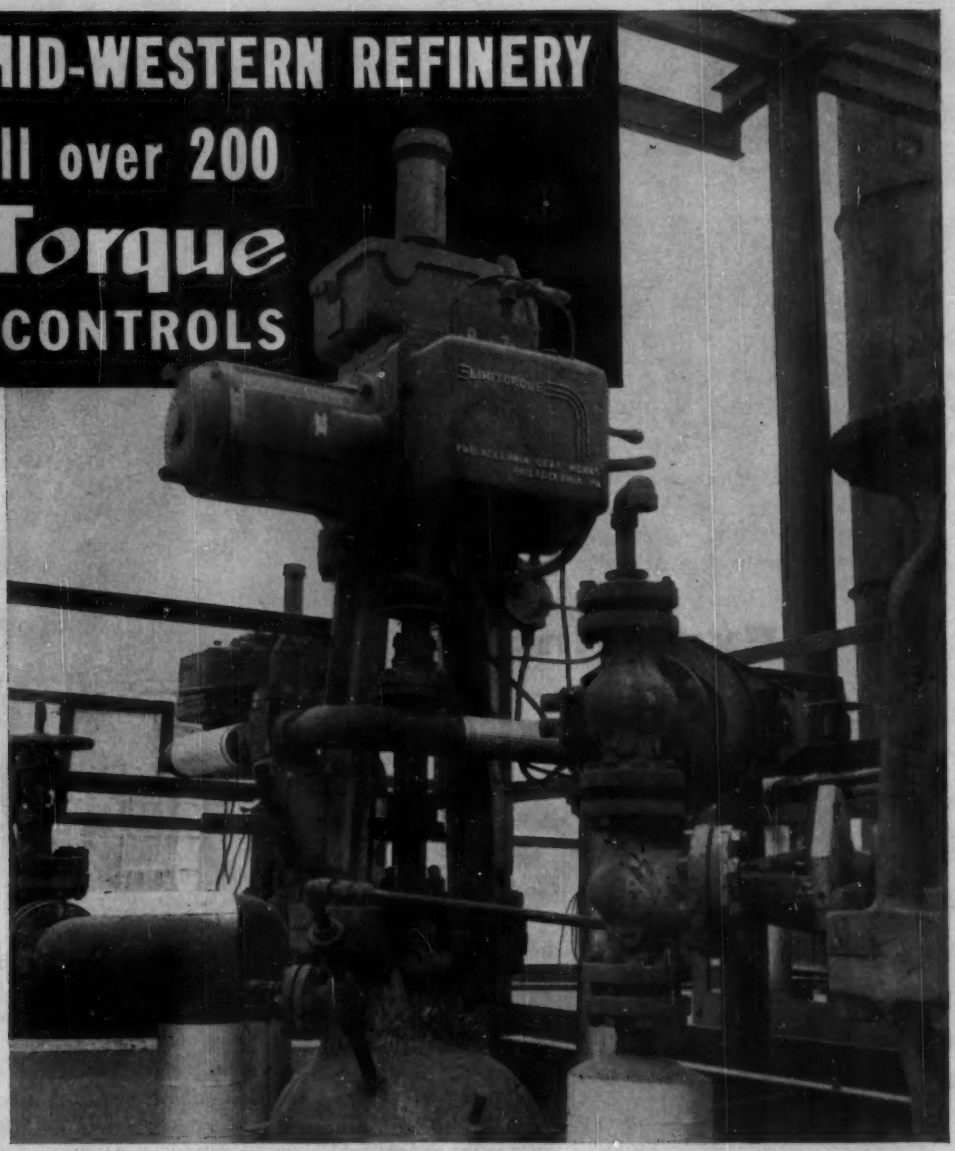
PRECIPITATOR-CYCLONE COMBINATIONS

But these aren't satellite launchers, though they're specially designed for high temperature operation: they're Buell extra-efficient cyclone dust collectors . . . and the new frontiers they're exploring are in industry. Everywhere in American industry, from cement mills to refineries, from chemical plants to power generating stations, Buell collectors set new records in percentage of dust removed, low maintenance, and improved plant operation. Even in the age-old field of fly ash collection, Buell extra efficiency pays off. Only *Buell* cyclones have the unique Shave-off port that traps small fines in the double eddy currents. And Buell large-diameter design eliminates bridging, clogging, or plugging. *All three* Buell Systems are illustrated and described in "The Collection and Recovery of Industrial Dusts". Write for a copy to Dept. 21-F, Buell Engineering Company, Inc., 123 William St., New York 38, N. Y.

buell®

Experts at delivering Extra Efficiency in **DUST COLLECTION SYSTEMS**

LARGE MID-WESTERN REFINERY uses well over 200 LimiTorque VALVE CONTROLS



. . . on Platinum Catalyst Reforming Units

The above illustration shows a LimiTorque Motorized Valve Control mounted on a 12", 600 lb. valve on a platinum catalyst reforming unit . . . This is just one installation of well over 200 such units used in this modern, well known refinery, and is but one of many thousands of LimiTorque controls used throughout the refinery field in America and foreign countries.

These LimiTorque units are of explosion-proof design having motors with Underwriters Labels . . . They are also equipped with position indicators which transmit valve position back to the control point.

There is no guesswork or labor connected with the LimiTorque Valve Controls . . . from a conveniently located control point, one key man can open and close any type of valve quickly and dependably in remote or hazardous locations.

LimiTorque may be actuated by any available power source, such as Electricity, Oil, Gas, Water or Air; and is available for Microwave control.

Send for Catalog L-550 for details.

LimiTorque®

PHILADELPHIA GEAR CORPORATION
ERIE AVE. & G STREET, PHILADELPHIA 34, PENNA.
Offices in all Principal Cities

INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID AGITATORS • FLEXIBLE COUPLINGS

Limitorque Corporation • Philadelphia

never before!

COMPACT, LOW-WEIGHT CONNECTORS WITH HIGH CURRENT RUPTURING RATINGS*

The new industrial series "C" Pyle-Star-Line connectors combine unique insulation and construction characteristics which make possible extraordinarily high circuit breaking ratings for the size and weight of the shell.

"Sandwich Insulation"—a resilient silicone insulation disc which floats between two rigid discs absorbs shock and vibration and permits the contacts to align themselves. The silicone, under pressure, reacts like a fluid. It flows into all crevices about the contact pins and sockets — positively prevents moisture or dust from passing through the insulation or accumulating to cause failures from short circuits or grounds.

Contact Inserts

Tough Anodic Coating of shell provides a smooth, attractive finish which has a hardness equal to 40 on the Rockwell C scale.

Rugged, Compact, Low-Weight Shell machined from high tensile strength aluminum...combined with the unique insulation features...provide a safe reliable, easy-to-handle connector which is highly resistant to the most punishing extremes of temperature, pressure, shock, vibration, corrosive dusts and moisture. Advantages never before combined in a single, standardized connector!

***Listed by Underwriters' Laboratories** in circuit breaking ratings of 30, 60, 100 and 200 ampere, 600 volt, A.C.

Write for 64-page catalog, No. 1252-I

THE PYLE-NATIONAL COMPANY

WHERE QUALITY IS TRADITIONAL

1393 North Kostner Avenue, Chicago 51, Illinois

BRANCH OFFICES AND AGENTS IN PRINCIPAL CITIES OF THE U.S. AND CANADA • CANADIAN AGENT: THE HOLDEN CO., LTD. MONTREAL • RAILROAD EXPORT DEPARTMENT: INTERNATIONAL RAILWAY SUPPLY CO., 30 CHURCH ST., NEW YORK 7, N.Y. • INDUSTRIAL EXPORT DEPARTMENT: ROCKE INTERNATIONAL CORP., 13 E. 40TH ST., NEW YORK 16, N.Y.

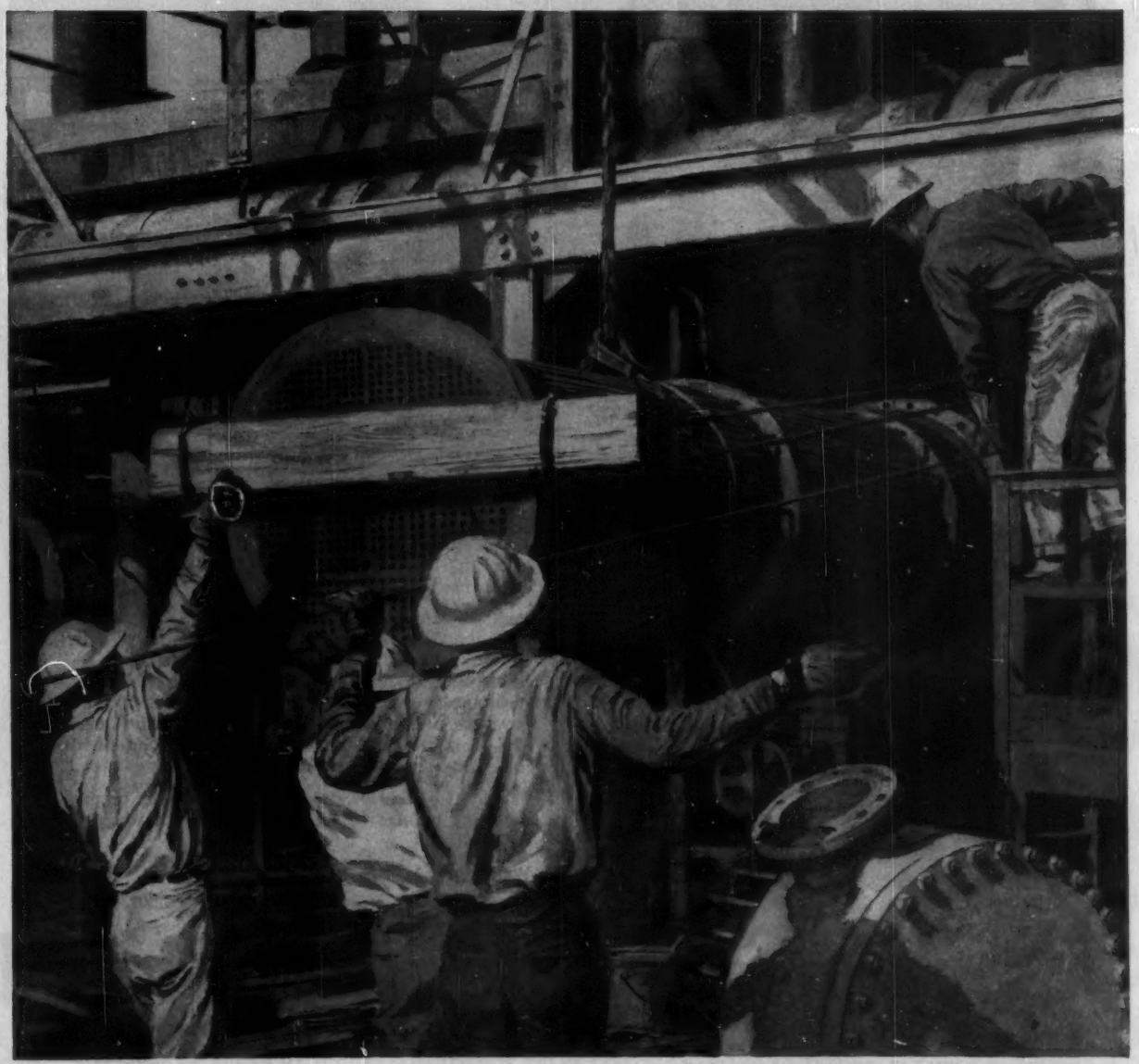
SINCE 1897

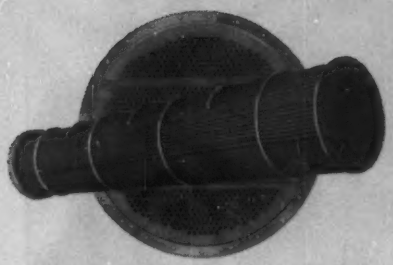
CONDUIT FITTINGS • PLUGS AND RECEPTACLES • LIGHTING FIXTURES • FLOODLIGHTS

RETUBE YOUR BUNDLES WITH

PHELPS DODGE HEAT EXCHANGER AND CONDENSER TUBES

FOR LONG-RUN RELIABILITY!





- Wide range of finest quality copper-base alloys—bi-metal combinations—to fit your application needs.
- Well-stocked, nation-wide warehouses at Houston, Tulsa, Los Angeles and Bayway, N. J.
- Experienced engineering staff at your service to help solve tube corrosion problems.

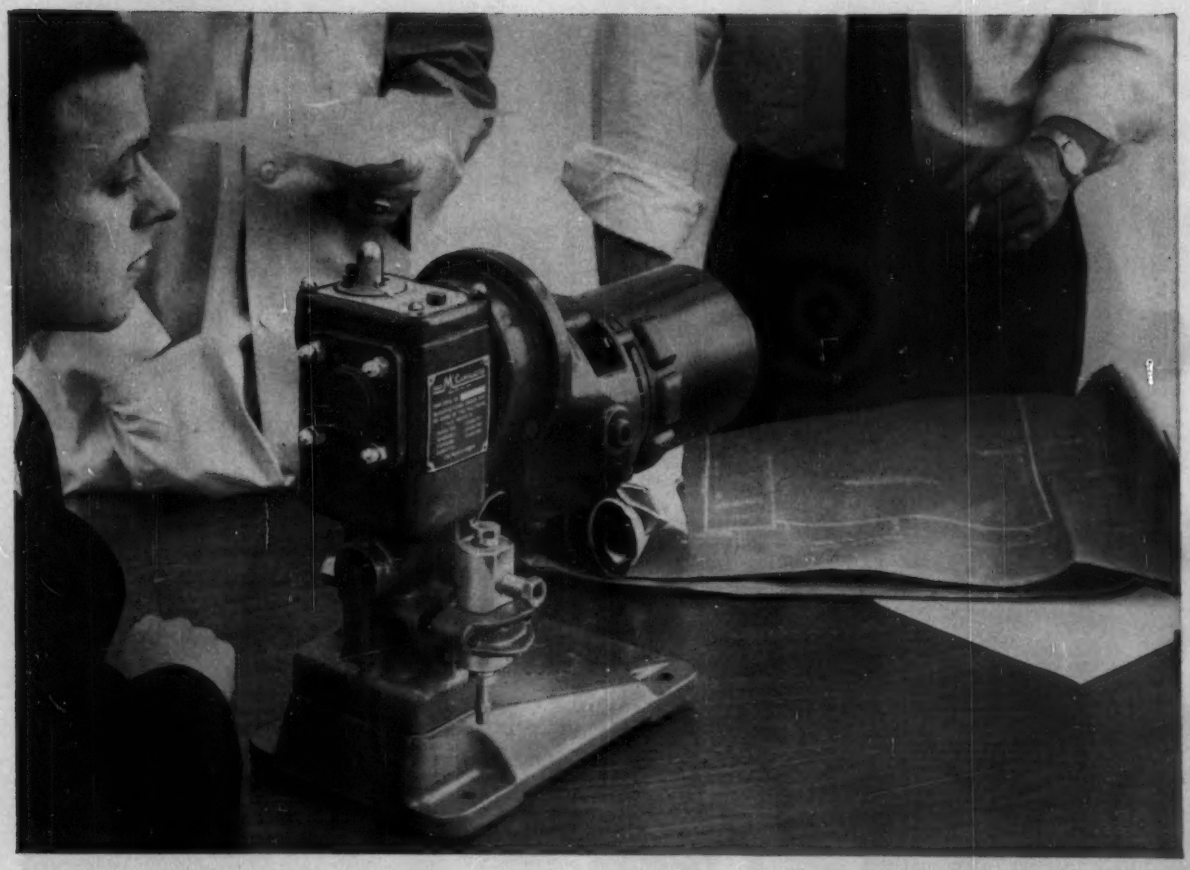
Specify Phelps Dodge . . . a leading manufacturer of tubes for the fabricators of heat exchangers and condensers!

PHELPS DODGE COPPER PRODUCTS CORPORATION

SALES OFFICES: Atlanta, Birmingham, Ala., Cambridge, Mass., Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Detroit, Fort Wayne, Greensboro, N. C., Houston, Jacksonville, Kansas City, Mo., Los Angeles, Memphis, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle, Washington, D. C.

FIRST FOR LASTING QUALITY—FROM MINE TO MARKET!

For more data on advertised products, use Readers' Service Cards, last page.



You're looking at a new metering pump that offers greater accuracy, takes less space

Meet the new McCannameter!*

Here you see management, laboratory and process personnel getting acquainted with a packless pump that provides accurate metering and proportioning over a wide output range. Each is interested in its new compact design that takes only ⅓ the space previously required. Each likes the continuous flow characteristics available through the entire capacity range. Capacity is adjustable while in operation . . . pumping at pressures up to 2500 psi. The McCannameter is available with either Teflon-faced diaphragm or metallic bellows, depending on your needs.

The new, improved McCannameter is ready to provide these same benefits in your industrial process, pilot plant or laboratory. It assures you of precision and dependability. To really get acquainted, send today for full information. * PAT. APPLIED FOR

SEND FOR NEW BOOKLET
"McCannameter—The Meter That Pumps" gives the inside story of precision, versatility and reliability. Write for your free copy of Booklet No. 302.

HILLS-McCANNA COMPANY
4614 West Touhy Avenue, Chicago 30, Illinois
Specialists in Diaphragm Valves and Proportioning Pumps

hills-mccanna company
THE PEOPLE WHO KNOW AND CONTROL FLOW

Complete Cost-Conscious Construction

the men, the method, the means . . .

Tellepsen engineers are qualified by years of experience to design the plants and processes required for every specialized phase of the petroleum and chemical industries. Use of scale models is an integral part of Tellepsen's cost-conscious planning procedure.

ECONOMIC RESEARCH & REPORTS
APPRAISALS • FIELD SURVEYS
PROCESSING • MODELS DESIGN

Tellepsen maintains a large staff of experienced mechanical, electrical and structural designers and draftsmen to translate the ideas of the planning group into working drawings.

DESIGN AND ENGINEERING

Major field installations are constructed by Tellepsen for the petroleum and chemical industries throughout the United States and in foreign countries.

FABRICATION
PROCUREMENT & EXPEDITING
CONSTRUCTION SUPERVISION
INITIAL PLANT START-UP

TELLEPSEN
PETRO-CHEM
CONSTRUCTORS

A Division of Tellepsen Construction Company

P. O. BOX 2536 • HOUSTON, TEXAS • TELETYPE HO-101

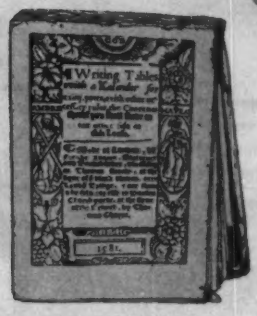
CABLE — "Tellecon"

MEXICO: Tellepsen de Mexico, S.A. de C.V. — Mexico, D.F. VENEZUELA: Trans-Caribbean, S.A. — Maracaibo, Ven.

LICENSED PROCESSORS FOR REFINERIES • LICENSORS FOR TELLEPSEN-DEVELOPED PROCESSES • ENGINEERS AND CONSTRUCTORS FOR THE PETROLEUM, CHEMICAL AND PETRO-CHEMICAL INDUSTRIES ANYWHERE IN THE WORLD.

Your enquiry will receive prompt, confidential attention—without obligation, of course.

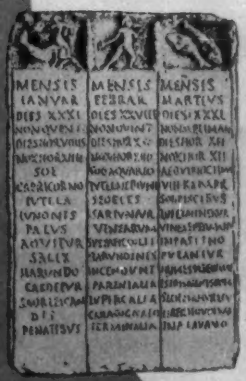
Scandinavian Calendar—Between 8th and 14th Centuries



English Tables—16th Century

Operating time of Clark Centrifugals

Roman Farmer's Almanac—1st Century A. D.



Saxon Calendar—About 6th Century

Aztec Calendar Wheel—Before 1479

For more data on advertised products, use Readers' Service Cards, last page.

totals 19 CENTURIES

Operating experience recorded by Clark centrifugal compressors totals 1,981 years. Providing rugged, reliable service 'round the clock, they have compiled this lengthy performance record within the actual time of only 10 years.

When Clark began to build centrifugal compressors a decade ago, pressures of 100 psi. were not considered practical. Today, as a result of Clark advanced engineering and design, Clark centrifugals are operating at over 5,000 psi. From the first, they have proved themselves in the field.

Clark builds two basic types of centrifugals. The horizontally split case type is designed for low to moderately high pressure ranges. The vertically split case type is used for extremely high pressure conditions. With capacities ranging from 1,000 to more than 150,000 CFM., Clark centrifugals are being used in new and ever widening applications throughout the world.

For all the facts about these performance-proved compressors backed by Clark's *encyclopedia of experience*, call your nearby Clark engineer. Or write today for Bulletin 150 to Clark Bros. Co., 1303 Lincoln Avenue, Olean, New York.

CLARK BROS. CO.

One of the Dresser Industries

Sales and service outlets in principal cities throughout the world

CLARK®

ONE OF THE DRESSER INDUSTRIES

CENTRIFUGAL COMPRESSORS

For more data on advertised products, use Readers' Service Cards, last page.

GUTS!

no other pipe insulation stands up like

tough UNIBESTOS

to save replacement and maintenance costs

UNIBESTOS® won't shatter from hammer blows . . . is undamaged by fumes, water, or moisture . . . yet cuts and fits easily—goes on quickly—may be removed and reused time after time without damage or loss of efficiency. Sizes to 44" o.d.; single-layer thicknesses to 5". The whole cost-cutting story is yours for the asking. There's only *one* UNIBESTOS!

Where lead gives useful corrosion control

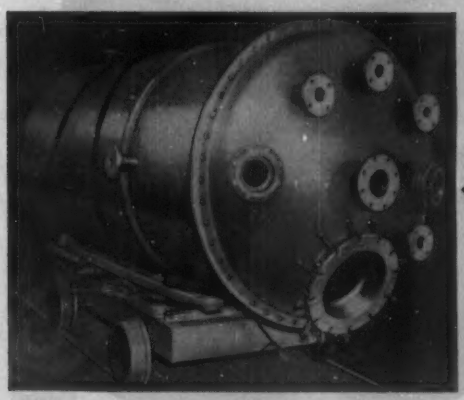
in liquid Sulphur Dioxide process vessels and piping

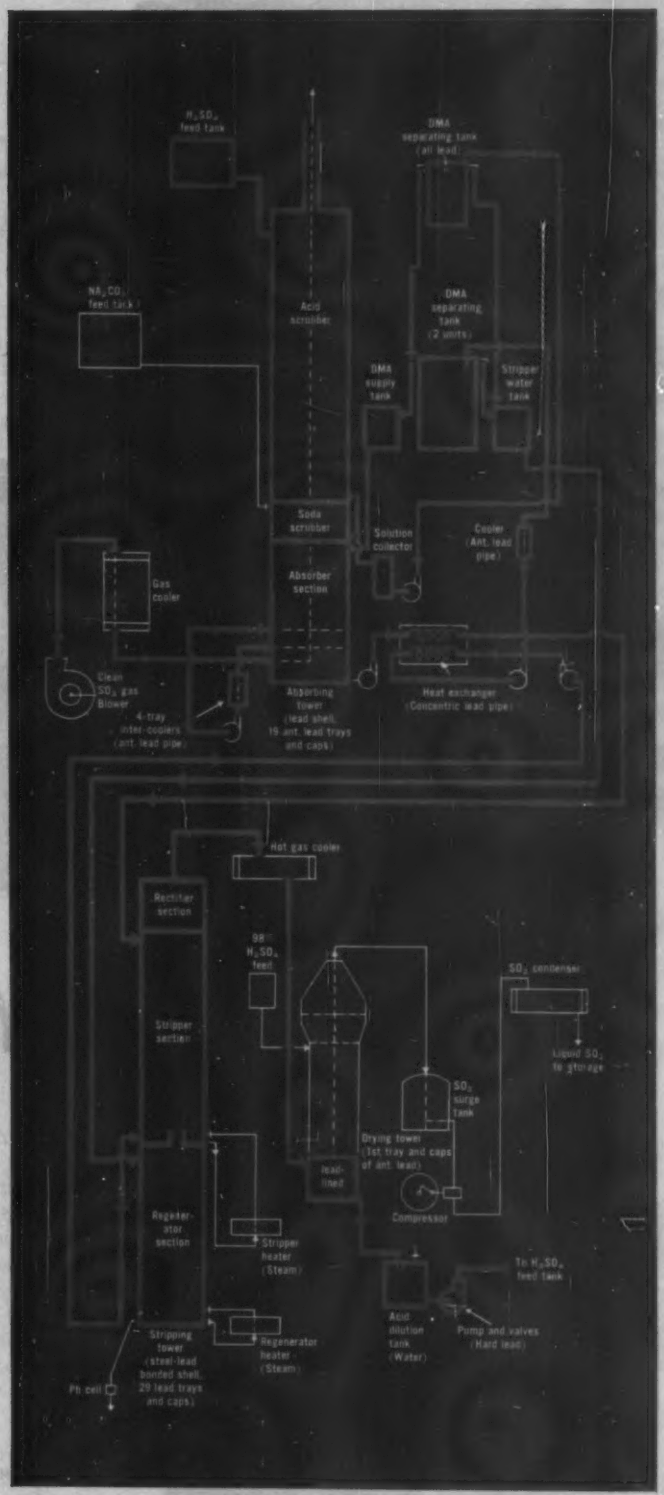
Hot SO_2 vapors and other oxidation products present in liquid SO_2 processing are "murder on metal." Even that old corrosive marauder, H_2SO_4 gets into the act.

As a result, *lead* practically lives with these acids and gases throughout the SO_2 process. In fact, the flow chart at the right is almost a continuous flow of *lead* applications. For ducts. For piping. For sheet lead linings in the larger units like the scrubbers and strippers. It is used with steel, with wood, with copper and, in some cases, with concrete. The result is low maintenance cost, facility of repair and consequent freedom from costly production stoppages.

If your process involves corrosive chemicals, look to *lead* for *long life, low maintenance and minimum loss of production due to down-time.*

When you think of Lead ...*think of* National Lead



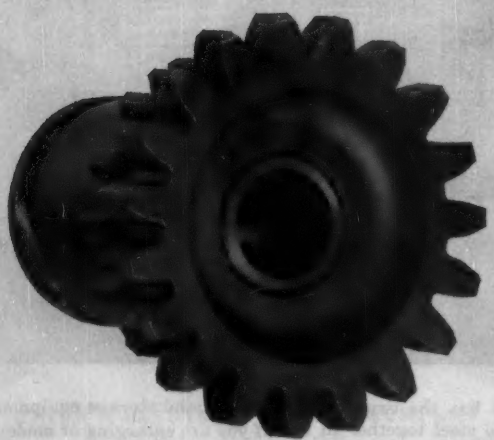


National Lead has the experience to get *lead* and steel together in a *bond* that defies severe pressure and temperature changes, vibration and creep. That's been proved not only in regular production "stock" items such as piping and valves but also in specially designed, complex lead process and storage equipment.

If you are enlarging or modernizing your processing facilities, now's a good time to get the facts about lead-lined equipment. Contact National Lead Company, Lead Lined Products, 111 Broadway, New York 6, New York.

For more data on advertised products, use Readers' Service Cards, last page.

CORROSION REALLY STOPPED!



Gears and pistons were used to illustrate the damage of corrosion more vividly. The basic idea of the ASTM Steam Turbine Oil Test in which probes are ordinarily used was not changed.

ARMOUR DUOMEENS® OFFER COMPLETE PROTECTION AGAINST CORROSION!

Here you see 2 pistons and gears after 20 hours in a modified ASTM Steam Turbine Oil Test. The piston and gear in the "control" oil-brine solution were badly corroded. *There was no corrosion on the lower piston and gear when only 60 ppm Duomeen salt was added to an identical solution. Both parts stayed as shiny and clean as when the test began!*

It is hypothesized that the Duomeen plated-out on the metal surface as a closely-packed mono-molecular film, enabling the surface to become preferentially oil-wettable. By such action, a highly effective diffusion barrier is formed, even at very low concentrations, which acts to inhibit corrosion.

Versatile Duomeens make all refinery products function better

Because these oil soluble organics are selectively adsorbed from oil to metal, they function as product additives, process corrosion inhibitors, and as chemical intermediates.

Diesel oils, lube oils, aviation gasolines, greases, automobile gasolines, #2 fuel oils—all can benefit from the Duomeens and other fatty amine derivatives in the following ways . . .

- Corrosion inhibitors in refinery products
- Sludge inhibitors in fuels and oils
- E.P. lubricants in hi-pressure oils and greases
- Oiliness agents in oils and greases
- De-icers in gasolines

These di-polar surface active agents are also being utilized in many other applications.

Refineries are using them as corrosion inhibitors throughout the entire refining process. Because of their adaptability, they have few equals when used as chemical intermediates. And new uses are still being discovered for the Duomeens.

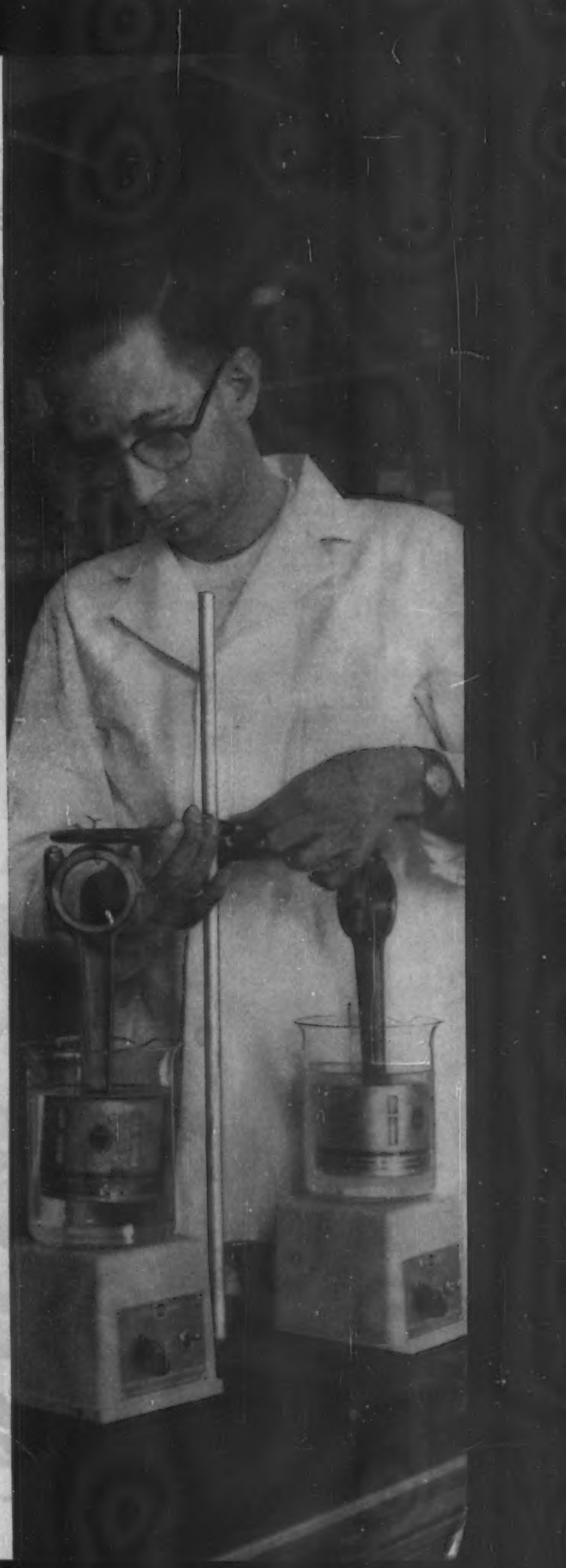
Armour petroleum specialists will help you utilize the right organic for your finished products, your flow lines and equipment. There is a Duomeen—or a Duomeen derivative—specifically designed to solve almost any refinery problem.

Send for the new Duomeen booklet, product samples and application information.

ARMOUR CHEMICAL DIVISION

Leader in Progressive Fatty Acid Chemistry

© Armour and Company • 1335 West 31st St. • Chicago 9, Ill.



Industry Standard for Lower Maintenance Costs

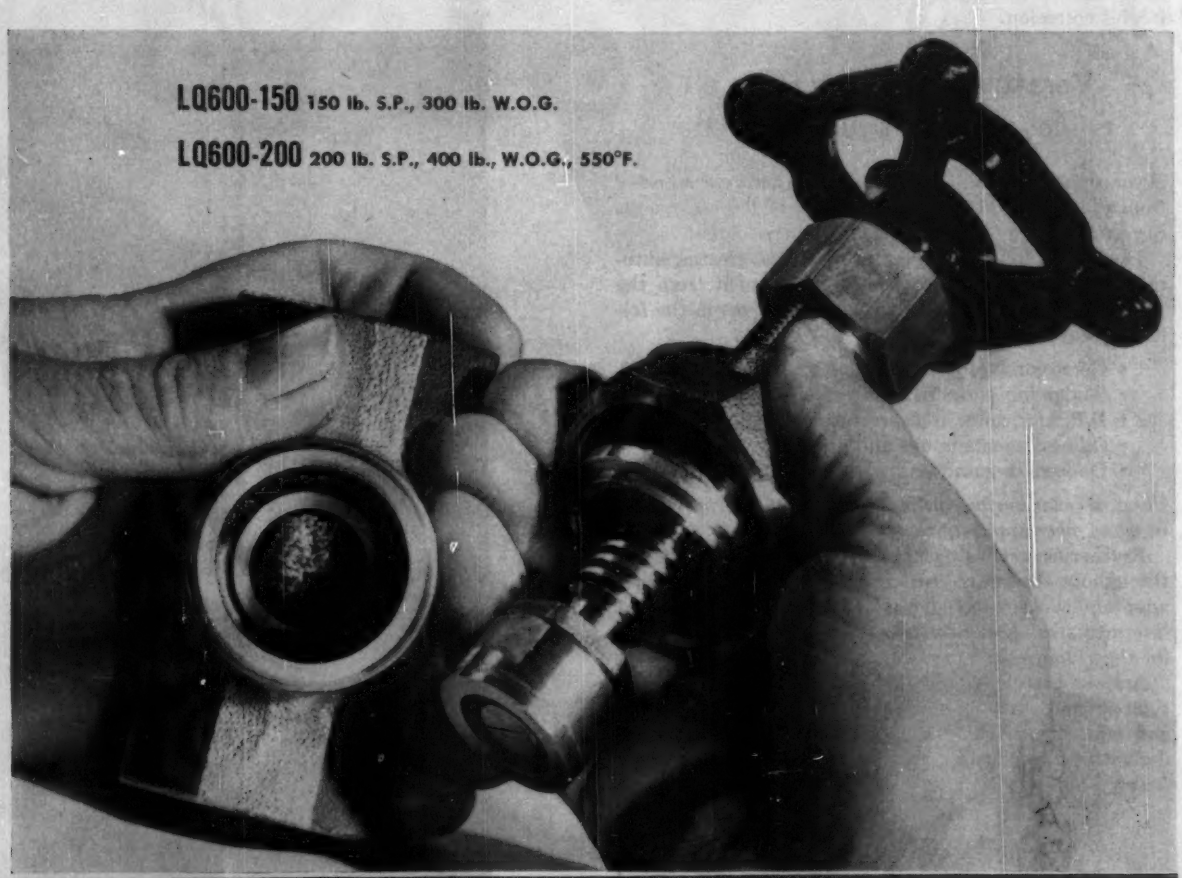
LQ600®

Here's Why: Long accepted valve maintenance costs are a thing of the past in thousands of plants where LQ600's have been installed . . . even in the most severe services where previous valves required repair or replacement after as little as two weeks on the line.

These outstanding savings are made possible by seats and discs of Brinalloy®, a patented Lunkenheimer alloy that is more resistant to wear and corrosion than 500 Brinell Stainless or 1000 Brinell Case-Hardened Stainless Steel.

Add to this the Lunkenheimer exclusive silicon-bronze Stemalloy®, the most durable stem material ever put into a valve, and you have two important reasons why LQ600's have established new low-maintenance standards everywhere they are installed.

For an actual comparison test, call the Lunkenheimer Distributor in your area. He is an expert on valve maintenance costs and will be glad to demonstrate the maintenance-saving benefits you receive when you install LQ600's . . . or write The Lunkenheimer Company, Cincinnati 14, Ohio



LUNKENHEIMER QUALITY

LUNKENHEIMER®

THE ONE *Great* NAME IN VALVES

For more data on advertised products, use Readers' Service Cards, last page.

SWARTWOUT AutroniC® INSTRUMENTATION

SECOND MAJOR BREAKTHROUGH IN SEVEN YEARS
THE UNITIZED AUTRONIC CONTROLLER

Swartwout revolutionized process control when it first introduced the AutroniC Control System in 1951. All limitations of the past were immediately swept away.

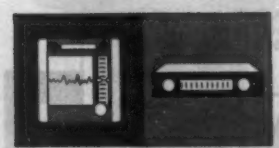
Impossible performance specifications became a reality. Zero hysteresis, infinite sensitivity and no signal lag became tangible qualifications that *only* this new instrumentation concept could fulfill.

Again in 1957, Swartwout amazed industry by producing the Unitized AutroniC design. Years ahead in its field . . . no control instrument has ever been as completely unitized. No controller has ever been as *practically* unitized in terms of flexibility and the simplest, easiest maintenance ever.

Every component section plugs in. They're all interchangeable. A simple indicator becomes a sophisticated recorder-controller in minutes and without tools.

In performance . . . maintenance . . . flexibility, you're years ahead with AutroniC Instrumentation. And, you'll stay ahead because of Swartwout continuing leadership in the control field.

4 new bulletins describe the Unitized AutroniC System. Request Bulletin Series A-801.



SWARTWOUT

. . . world leader in electronic process instrumentation

THE SWARTWOUT COMPANY
18511 EUCLID AVENUE,
CLEVELAND 12, OHIO

S-A. 1660

For more data on advertised products, use Readers' Service Cards, last page.

Pacific Process Pump **EXTRAS** bring **EXTRA PROFITS** to you!

MAXIMUM PARTS INTERCHANGEABILITY
is an extra feature in
PACIFIC PROCESS PUMPS

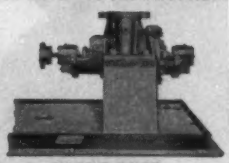
EXTRA CORROSION ALLOWANCE—All Pacific Process pumps are custom-built with case casting thickness in excess of actual pressure-temperature requirements. This provides a liberal allowance for corrosion-erosion and a high safety factor.

EXTRA HEAVY CONSTRUCTION—Pacific process pumps are engineered to combine the strength necessary for continuous heavy duty service with design simplicity and accessibility for low maintenance cost. All parts in contact with pumped liquid may be fabricated from any commercially available ferrous or non-ferrous metal.

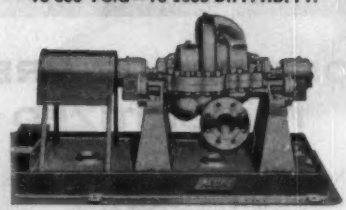
EXTRA LONG LIFE—Guided inlet flow reduces friction losses—insures minimum required NPSH. Dynamically, radially, and axially balanced moving parts eliminate vibration that would cause damage to rings, bushings, bearings, packing or mechanical shaft seals and excessive radial and thrust loads on bearings. Result—greatly increased availability for profitable operation.

Write for bulletins—please specify pump type.

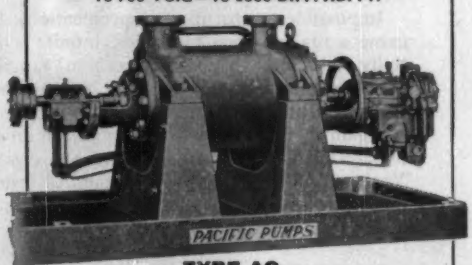
TYPE SVC
To 850°F.—25 to 3200 GPM
To 600 PSIG—To 650 DIFF. HD. FT.



TYPE HVC
To 850°F.—600 to 4500 GPM
To 600 PSIG—To 1000 DIFF. HD. FT.



TYPE RHC
To 500°F.—50 to 3000 GPM
To 700 PSIG—To 1300 DIFF. HD. FT.



TYPE AC
To 850°F.—100 to 2500 GPM
To 1000 PSIG—To 2600 DIFF. HD. FT.

PACIFIC PUMPS INC
A Division of Dresser Industries, Inc.
HUNTINGTON PARK, CALIFORNIA

PACIFIC

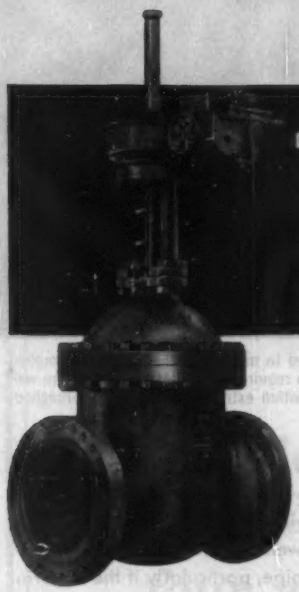
Offices in All Principal Cities

CP-19

Check this DARLING gate valve trio for

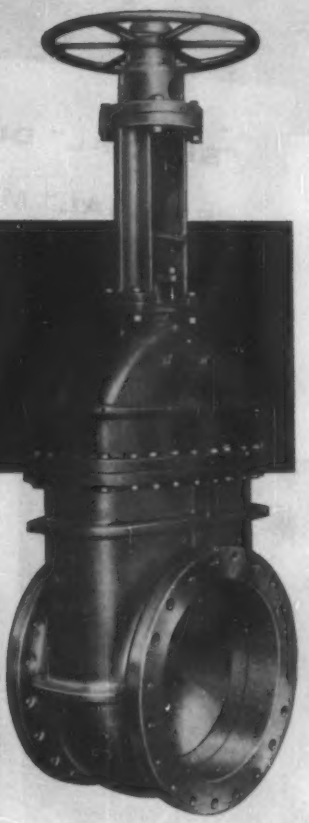
UNMATCHED ADVANTAGES

in every oil, gas and petrochemical service



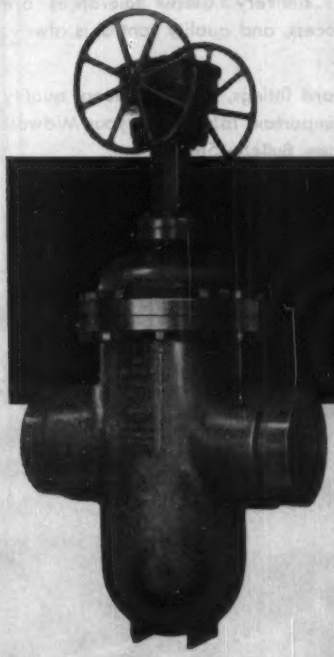
DARLING FULLY REVOLVING DOUBLE DISC GATE VALVES

—famous for *consistently* trouble-free operation in all kinds of service. Revolving disc principle assures easy operation, surer closure, minimum friction, automatic seating compensation, extreme life with minimum maintenance. Ask for Catalog 57.



DARLING ALUMINUM ALLOY GATE VALVES

—featuring all the advantages of the above revolving disc principle, *plus* new economies in the handling of "problem" fluids and gases or wherever aluminum piping is used. Ask for Bulletin SLS 5801.



DARLING-McEVOY SELF-SEALING CONDUIT VALVES

—the *only* conduit gate valve with *sealant gasketing* between gates and seats. Every closure leak-proof! This and other advantages proved by outstanding performance on major lines. Get *all* the facts. Ask for Catalog 57.

Whatever the service, in any phase of pipelining, gathering or processing, these Darling gate valves offer worthwhile features and advantages unobtainable in other valves. The catalogs referred to above are available to give you the pertinent facts.

DARLING VALVE & MANUFACTURING CO.

Williamsport 31, Pennsylvania

Manufactured in Canada by Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ont.

"SPECIAL" Welding Fittings

by MIDWEST

"SPECIAL" DESIGNS

"SPECIAL" MATERIALS

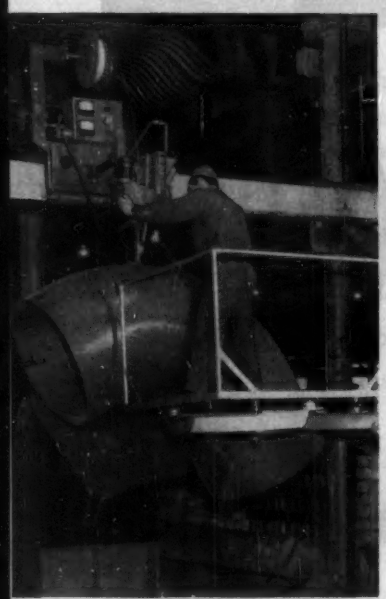
"SPECIAL" QUALITY

"SPECIAL" DELIVERY

Special gauges and instruments are used to make sure that we have complied with the extremely close tolerances often required on stainless fittings. Here wall thickness and concentricity were held within extremely close limits throughout the fittings.

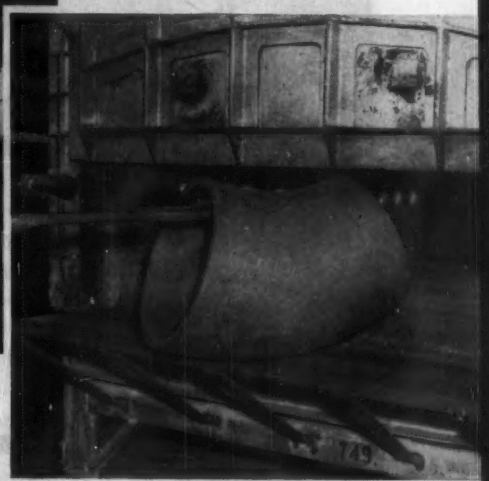
The exclusive Midwest method of manufacture—much more versatile and flexible than any other—enables us to make almost any type of special welding fittings to the most rigid specifications. Midwest makes welding fittings from *plate* . . . usually much easier to get than pipe, particularly if the material is special. That expedites delivery. Closer tolerances are inherent in the Midwest process, and quality control is always beyond code requirements.

Even if you use only standard fittings, the exceptional quality of Midwest fittings can be important to you. Ask your Midwest distributor or write us for new Bulletin 5801.



36" O.D. 90° elbow with 16" tangent on one end being welded by an automatic submerged arc machine. Material is A-201 carbon steel.

Stainless-clad elbows undergoing ultrasonic inspection to check bonding of material and quality of weld. Since plate is often the only form in which clad material is available, the Midwest process is able to produce the most comprehensive range of clad fittings—and to do so promptly.



Special 24" x 21" 45° reducing elbow made of 1" thick 1¼% chrome ½% moly steel ready for heat treating furnace.

MIDWEST PIPING COMPANY, INC.

Main Office: St. Louis 3, Mo. (P. O. Box 433)

PLANTS: ST. LOUIS, CLIFTON, N. J. and LOS ANGELES

SALES OFFICES:
Asheville (Box 446, Skyland, N.C.) • Atlanta 9—72 11th N.E.
Boston 27—426 First St. • Chicago 3—79 West Monroe St.
Cleveland 14—616 St. Clair • Houston 2—1213 Capitol
Los Angeles 33—520 Anderson • Miami 34—2103 Le Jeune
New York 7—50 Church St. • Pittsburgh 19, Pa.—437 Grant
San Francisco 11—420 Market St.
St. Louis 4, Mo.—1450 South Second St.

STOCKING DISTRIBUTORS IN PRINCIPAL CITIES

8059

Fast Delivery of Sola-Flex® Expansion Joints...cuts costly down time!

Proven, dependable Sola-Flex Joints can be "in service" one to four weeks after receipt of order!

In power or processing plants, failure of a single expansion joint can mean slower production, expensive repairs, even complete shutdown. That's why, when faced with possible trouble, you want replacement joints *fast!* And you want joints that will protect against future unscheduled down time. Solar makes the world's most complete line of expansion joints. They are made in a wide variety of stainless and high alloys, are available in a complete range of sizes and styles, withstand difficult extremes of temperature and pressure. Best of all, rugged Sola-Flex joints can be "in service" in one to four weeks . . . *or less!* For a new Sola-Flex catalog, write to Dept. F-27, Solar Aircraft Company, San Diego 12, Calif.

SOLAR
AIRCRAFT COMPANY

SOLAR
SAN DIEGO
DES MOINES

For more data on advertised products, use Readers' Service Cards, last page.

Struthers Wells

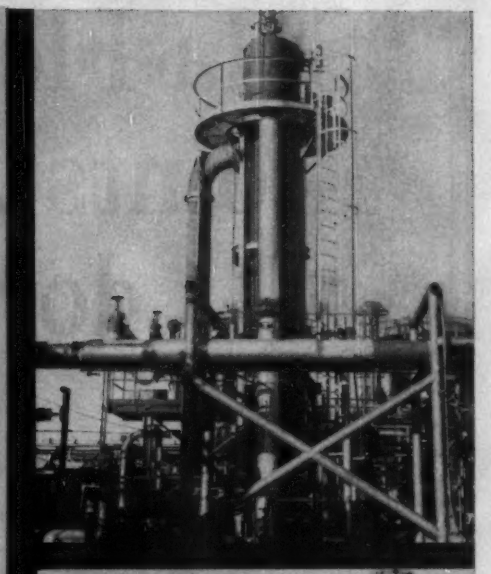
waste heat boilers steam generators

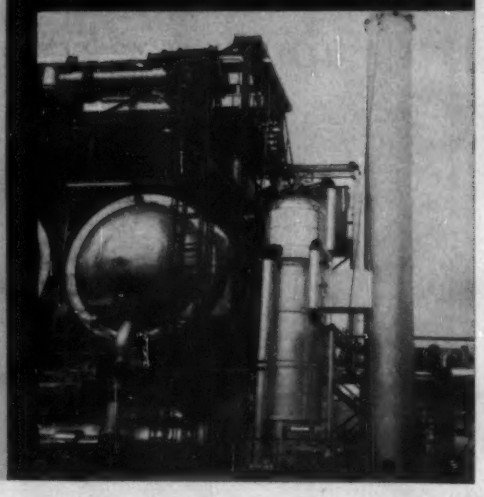
Struthers Wells offers a standard line of Waste Heat Boilers for the recovery of heat from gases and liquids. Four basic types are supplied, to handle a wide range of pressure and temperature, and for special process requirements.

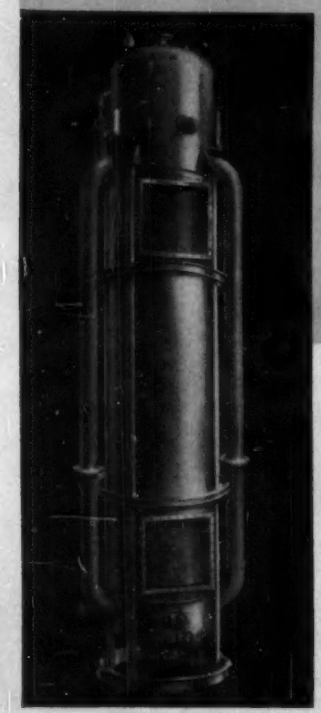
The Struthers Wells WV unit illustrated is designed to recover heat from gas turbine exhaust, high temperature catalytic reactors, and for many other services.

A number of large units are in service for leading chemical and petrochemical companies. The application photos show typical field views; the bottom photo showing one of two units installed for cooling gases from dehydrogenation reactors at a butadiene plant. The upper photo shows one of four units installed in a chemical plant.

If heat is available in high temperature gases or liquids, we will be glad to recommend and quote on equipment for steam generation at the required pressure.







Write!
Bulletin A-60 describes this equipment and is available on request.

STRUTHERS WELLS CORPORATION

WARREN, PENNA.
Plants at Warren and Titusville, Pa.

Struthers Wells

STRUTHERS WELLS PRODUCTS

PROCESSING EQUIPMENT DIVISION

Crystallizers . . . Direct Fired Heaters . . . Evaporators . . . Heat Exchangers . . . Mixing and Blending Units . . . Quick Opening Doors . . . Special Carbon and Alloy Processing Vessels . . . Synthesis Converters

BOILER DIVISION

BOILERS for Power and Heat . . . High and Low Pressure . . . Water Tube . . . Fire Tube . . . Package Units

FORGE DIVISION

Crankshafts . . . Pressure Vessels . . . Hydraulic Cylinders . . . Shafting . . . Straightening and Back-up Rolls

For more data on advertised products, use Readers' Service Cards, last page.

NEW "MIRROR-FINISH" ON GARLOCK METAL PACKINGS

...provides positive sealing at no extra cost

Now all Garlock Metal Scraper and Packing Rings have a surface finish of 10 micro-inches or less! And flatness of the rings is measurable in light bands; which means a more positive seal between ring and groove. This exclusive Garlock advantage has been made possible through improved manufacturing technique and is offered to you without additional cost.

Garlock Metal Packings with the exclusive "Mirror-Finish" are another part of the famous "Garlock 2,000" . . . two thousand styles of packings, gaskets, and seals for every need. The only complete line. That's why you get unbiased recommendations from your Garlock representative. Call him or write for Metal Packings Folder 3888-9.

Floating Metal Packing Sets are designed for use on reciprocating rods of air and gas compressors; steam and gas engines. Available in either solid cup or split-case design. Solid cup design (illustrated at right) withstands pressures to 30,000 psi.

Garlock Metal Packing Rings of graphitic cast iron, bronze, carbon, bakelite and babbit are precision made to exact specifications of size and finish assuring maximum efficiency.

THE GARLOCK PACKING COMPANY, Palmyra, New York

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

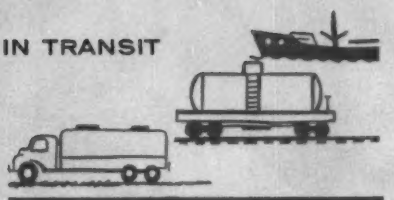
Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

another product of quality
from TRETOLITE

KUPLEX
METAL DEACTIVATOR

PREVENTS
HYDROCARBON
DETERIORATION
CAUSED BY
METAL CATALYZED
OXIDATION

IN TRANSIT



IN STORAGE

IN DISTRIBUTION

Contamination by copper speeds up the formation of gum, sedimentation and color degradation in light hydrocarbons. This can occur even after the product has left the refinery and can be controlled only by the use of an effective deactivator.

KUPLEX, Tretolite's new metal deactivator, offers the refiner this kind of follow-through for his product's quality—at minimum cost.

KUPLEX deactivates harmful copper compounds by a highly effective chelating action. This prevents hydrocarbon deterioration caused by accelerated metal-catalyzed oxidation.

KU-58-1

TRETOLITE COMPANY
DIVISIONS OF PETROLITE CORPORATION

369 Marshall Avenue, St. Louis 19, Missouri
5515 Telegraph Road, Los Angeles, 22, California

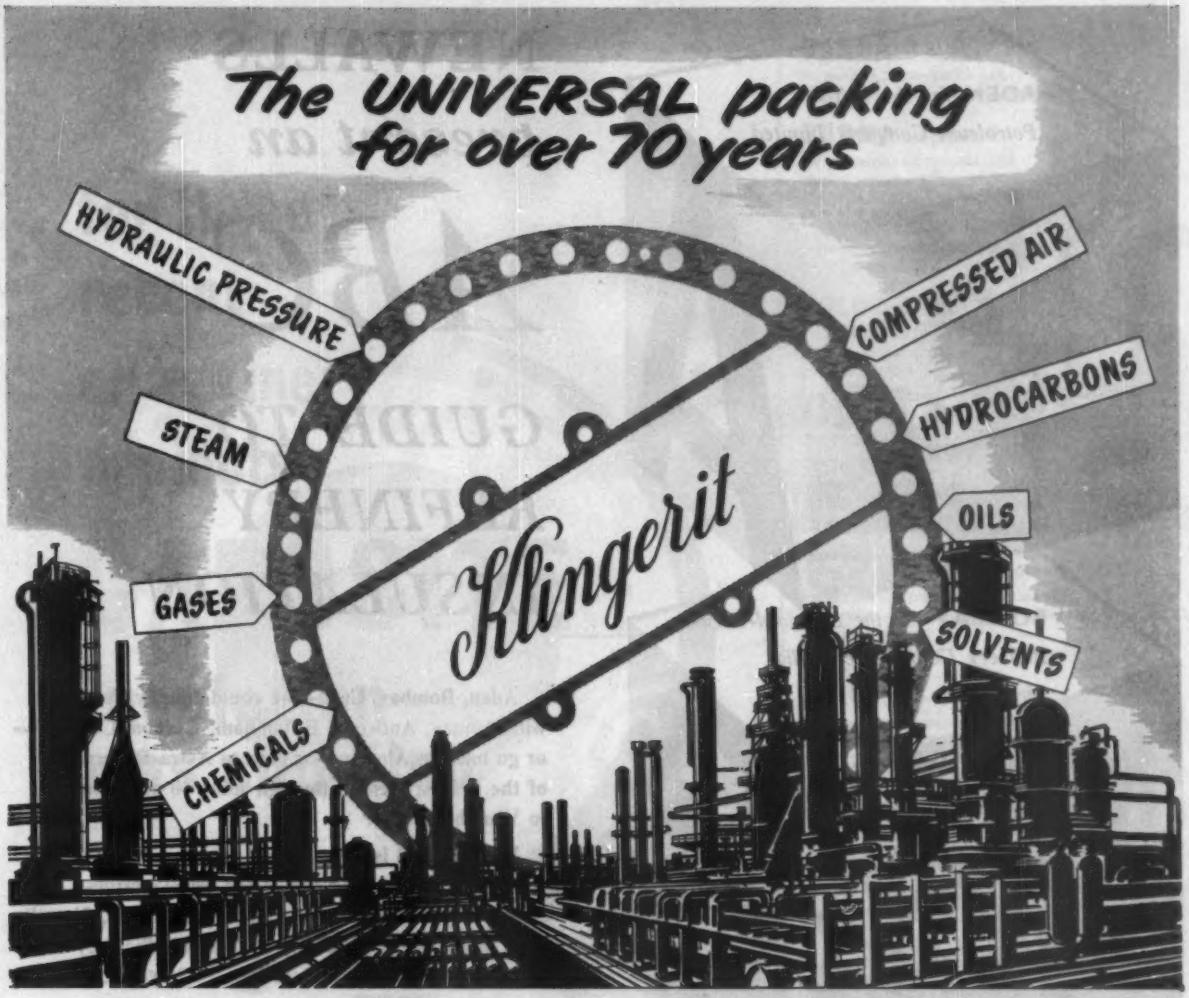
Chemicals and Services for the Petroleum Industry
DESALTING • CORROSION INHIBITING • DEMULSIFICATION
SCALE PREVENTION • WATER DE-OILING
METAL DEACTIVATION • ADDITIVES

effective quality protection
for such hydrocarbons as:

GASOLINE
JET FUEL
FURNACE OIL
KEROSINE
DIESEL OIL
TURBINE OIL

For more data on advertised products, use Readers' Service Cards, last page.

The UNIVERSAL packing for over 70 years



Know-how counts with packings—there is no substitute for experience. Klingerit compressed asbestos sheet packing has 70 years experience of manufacture behind every piece—no wonder it is relied on when engineers want joints to last!

Klingerit and its companion special purpose Klinger sheet packings provide sure answers to your packing problems. In sheets, ready cut joint rings or the largest precision made heat exchanger gaskets, the name Klinger guarantees top quality.

KLINGERIT: Universally used for steam, chemicals, gases and hydrocarbons at temperatures up to 500°C and pressures up to 6,000 p.s.i.

KLINGERIT 1000: Wire reinforced for extreme temperatures and pulsating pressures.

KLINGER-ACIDIT: Specially made to resist hot nitric, sulphuric, hydrochloric and organic acids.

KLINGER-OILIT: Bonded with synthetic rubber for maximum resistance to oils, hydrocarbons, refrigerants and solvents.

R.K.: An excellent packing for general engineering practise and other less severe conditions.

Our technical staff will be glad to give you further information. Write today for the Complete Klinger Packing Catalog.

RICHARD KLINGER INC. 550, FOURTH AVENUE, BROOKLYN 15, NEW YORK
SOUTH 8-6747

Manufacturing Licensees for Canada

JOSEPH ROBB & COMPANY LIMITED, 5575, COTE ST. PAUL ROAD, MONTREAL, 20, CANADA
Telephone: GLENVIEW 9151

Branches at: SYDNEY, HALIFAX, OTTAWA, TORONTO, HAMILTON, WINNIPEG, EDMONTON, VANCOUVER, QUEBEC CITY

RICHARD KLINGER LIMITED, KLINGERIT WORKS, SIDCUP, KENT, ENGLAND.

GA44/58/I

For more data on advertised products, use Readers' Service Cards, last page.

ADEN for the British Petroleum Company Limited
A
BOMBAY for the Standard-Vacuum Refinery Company of India Limited
B
CUBA for Cia. Petrolera Shell de Cuba
C

NEWALLS *present an*

ABC

GUIDE TO REFINERY INSULATION

Aden, Bombay, Cuba—we could equally well start with Amuay, Antwerp, Billingham, Cardon, Cubatao—or go back to Abadan—or even to Astra-Romana of the 1920's, then on through some 40 oil refineries to Visakhapatnam.

Wherever oil is to be refined you are likely to find Newalls insulation. As one of the world's largest heat insulation manufacturers and contractors, Newalls have contributed extensively to thermal efficiency in this highly specialised field for over 25 years.

Newalls supply a range of insulating materials to operate at temperatures from —300°F. up to over 2,000°F. that have proved themselves in oil refineries and petrol-chemical plants in most countries.

Newalls also provide a Technical Advisory Service with long experience of all types of insulation questions from design to completion.

Newalls

NEWALLS INSULATION CO. LTD.

Head Office:

Washington, County Durham, England

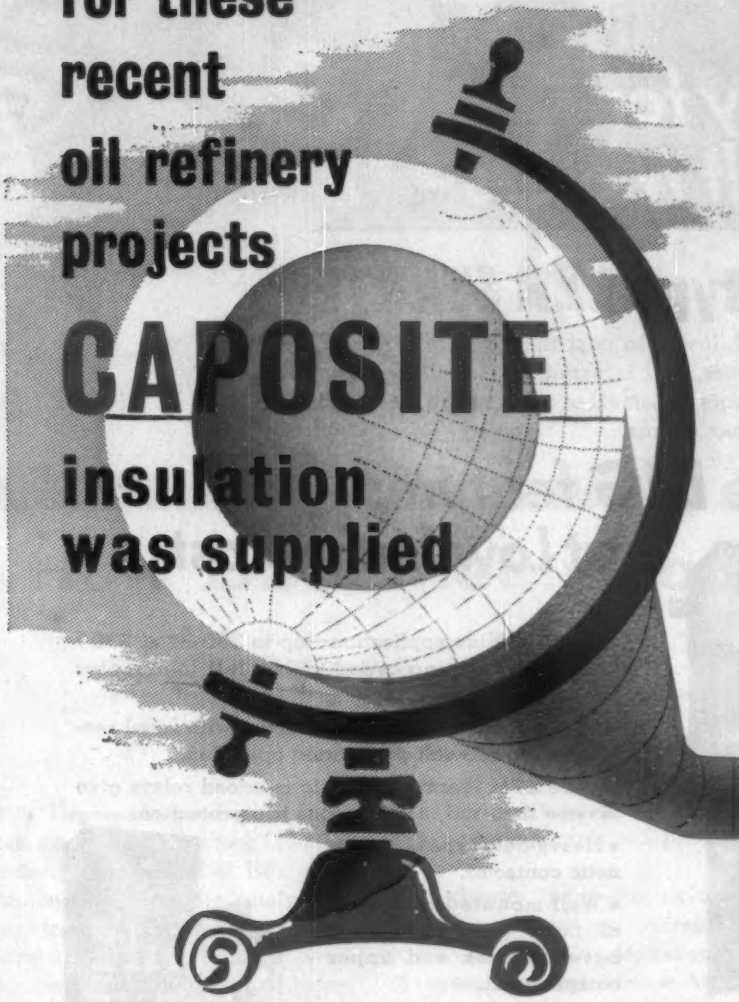
A member of the TURNER & NEWALL ORGANISATION

AGENTS AND VENDORS IN MOST MARKETS ABROAD

For more data on advertised products, use Readers' Service Cards, last page.

for these recent oil refinery projects

CAPOSITE insulation was supplied



BAHRAIN *at Awali*
for Bahrain Petroleum Co. Ltd.
Main Contractor: Foster Wheeler Ltd.

BURMA *at Syriam*
for The Burma Oil Co. (1954) Ltd.
Main Contractor: Foster Wheeler Ltd. (London)

CANADA *at Clarkson, Ontario*
for British American Oil Co. Ltd.
Main Contractor: The Lummus Co.

COLOMBIA *at Cartagena*
for International Petroleum Co. Ltd.
Main Contractor: Bechtel Corporation
(Insulation Contractor: Harold Aber & Co.)

ECUADOR *at La Libertad*
for the Anglo-Ecuadorian Oil Co. Ltd.
Main Contractor: Procon (G.B.) Ltd.

ENGLAND *at Kent Oil Refinery*
for The British Petroleum Co. Ltd.

FRANCE *at Raffinerie de Normandie*
for Compagnie Francais de Raffinage.
Main Contractors: Kellogg International Corporation and Foster Wheeler Ltd. (France).
(Insulation Contractor: Soc: Technisol).

IRAQ *at Daura, near Baghdad*
for Iraq Government Oil Refinery Administration.
Main Contractor: Foster Wheeler Ltd. (London).

ITALY *at Genoa*
for Raffineria Dottore E. Garrone.
Main Contractor: C.T.I.P.

KUWAIT *at Akmadi*
for the Kuwait Oil Co. Ltd.
Main Contractors: Bechtel-Wimpey and E. B. Badger & Sons Ltd.

THE NETHERLANDS *at Pernis*
for N. V. de Bataafsche Petroleum Maatschappij.

NETHERLANDS ANTILLES
at C.P.I.M. Refinery, Curacao
for Royal Dutch-Shell Group.

SCOTLAND *at Grangemouth*
for British Hydrocarbon Chemical Co. Ltd.
Main Contractor: E. B. Badger & Sons Ltd.

VENEZUELA *at Maracaibo*
for The Richmond Exploration Co.
Main Contractor: The Lummus Co.

CAPOSITE regd.

Amosite Asbestos Blocks and Pipe Sections

Speedy application .... long-lasting protection .... resilience to withstand rough handling .... long fibred Amosite asbestos, giving superior insulating properties — these are the reasons why CAPOSITE is being specified for more and more of today's refineries.

CAPOSITE *is also manufactured in*
SOUTH AFRICA, ITALY, CANADA, FRANCE, HOLLAND, SPAIN

THE CAPE ASBESTOS COMPANY LTD
114 & 116 PARK STREET, LONDON, W.1
Tel: GROsvenor 6022 Cables: Incorrupt London

Enquiries in Canada to:
Cape Asbestos (Canada) Ltd., 200 Bloor Street East, Toronto, Ont.
U.S.A. to: North American Asbestos Corpn., Board of Trade Building, Chicago, 4, Illinois

CAPE

TA 415

For more data on advertised products, use Readers' Service Cards, last page.

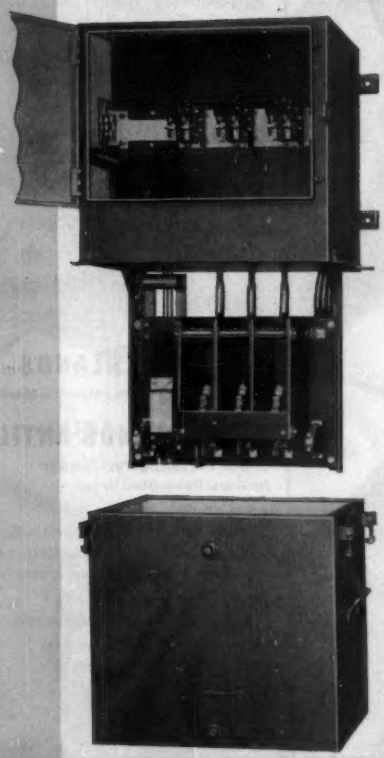
Designed

Specifically for 2300-volt Motors –

NEW EC&M type LZH STARTER

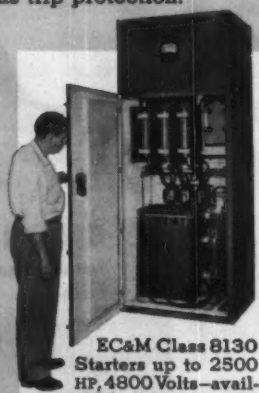
This new starter is compact, lower in cost than EC&M's Type ZHS high capacity oil-break starters, and is especially designed for use where short circuit requirements are small or where high interrupting protection is provided by other means.

You Get these BIG features – at Low Initial Cost



- Wide application—up to 350 HP at 2300 volts. Interrupting capacity 10x full load motor current.
- Self-contained Control Transformer with fused secondary for 220-volt pushbutton operation.
- Type ZTM thermal-magnetic overload relays give inverse time and instantaneous trip protection.
- Heavy-duty Type LZH magnetic contactor.
- Wall-mounted with drop oil tank. Anti-syphon leads between tank and upper compartment.
- Control leads brought to terminal board. Incoming and outgoing cables equipped with solderless power lugs.
- High and low voltage separated by insulating barrier.

Write for Bulletin 8121



EC&M Class 8130 Starters up to 2500 HP, 4800 Volts—available in 3 styles: *(1)* 50,000 KVA *(2)* Power Fused and *(3)* VALIMITOR (unlimited protection without fuses)

THE ELECTRIC CONTROLLER & MFG. CO.

A DIVISION OF THE SQUARE D COMPANY

CLEVELAND 28 • OHIO

1237

How B&A® meets your needs for

BORON TRIFLUORIDE

Gas and Complexes

With large-scale production . . . Baker & Adamson has long been the leader in production of BF_3 gas—shipping this versatile catalyst in large trailer trucks like those you see being loaded above. B&A pioneered this method of shipment and today has a fleet of these trucks always on the road, serving the needs of the process industries.

With reference data . . . Baker & Adamson has compiled a considerable amount of reference data on the applications of Boron Fluoride gas and complexes. Boron Fluoride's wide range of applications and its cost-cutting production advantages—such as its ease of catalyst removal—make it a factor to be considered in almost any organic synthesis problem.

Mail coupon today—for technical data on properties and typical uses of B&A Boron Trifluoride gas or any of the complexes listed below. Attach company letterhead, please.

Boron Fluoride Ether (Diethyl) Complex
Boron Fluoride Phenol Complex
Boron Fluoride Diacetic Acid Complex
Boron Fluoride Di-n-Butyl Ether Complex
Boron Fluoride Dihydrate
Boron Fluoride Ethyl "Cellosolve" Complex
Boron Fluoride Hexamethylenetetramine Complex
Boron Fluoride Monoethylamine Complex
Boron Fluoride Para-cresol Complex
Boron Fluoride Triethanolamine Complex
Boron Fluoride Urea Complex

GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N. Y.

Allied Chemical

Mail Coupon for Data

BAKER & ADAMSON® Fine Chemicals
GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N. Y. PR-6

☐ Please send general information on properties and uses of Boron Trifluoride gas ☐

_____ complex ☐

☐ Please send information on Boron Trifluoride for the following application:

_____

_____

Name _____

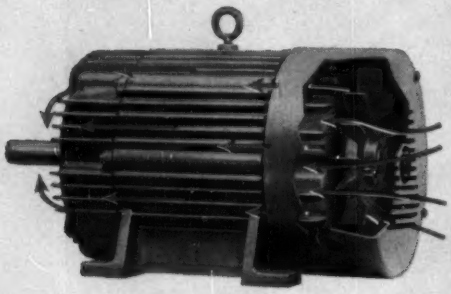
Position _____

Company _____

Address _____

City _____ Zone ____ State _____

For more data on advertised products, use Readers' Service Cards, last page.



The original C-W fin-cooled, self-cleaning design which provides more cooling area—no internal passages to clog.

ELLIOTT C-W EXPLOSION-PROOF MOTORS

self-cleaning . . . self-cooling

Designed especially for hazardous locations

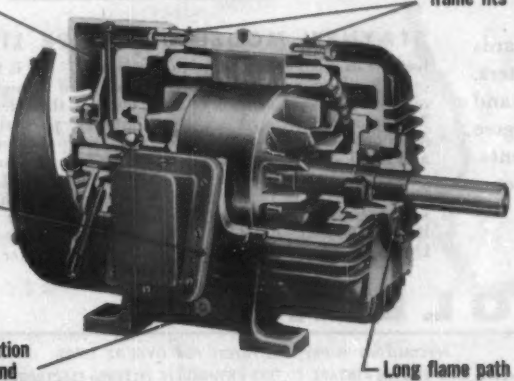
Elliott explosion-proof sealedpower motors are approved by Underwriters' Laboratories for applications in hazardous locations, indoors or outdoors. They have an excellent service record in refineries, natural gasoline plants, pipe lines, chemical plants, etc. . . . wherever explosive atmospheres may exist. NEMA frames through 505, ratings to 100 hp. Ask your Elliott representative for detailed literature *today*.

ELLIOTT Company

CROCKER-WHEELER PLANT, Jeannette, Pennsylvania

W 8-3

5 important construction features provide safety and reliability


Non-sparking external fan
Long bracket-to-frame fits
Close-tolerance metal-to-metal fits; leads sealed where they leave frame
Approved combination automatic drain and breather—easy to get to
Long flame path and rotating slinger

Underwriters Approved—for Class I, Group D, frames 182 through 256U . . . for Class I, Group D, frames 284U through 326U . . . for Class I, Group D and Class II, Groups F and G, frames 364 through 505

KEEP IT CLEAN

by Phil Tration

A spinster maid, name of Sue
Cleaned house with a Filter, Staynew
Her Boss was so gratified, so thoroughly satisfied
He upped and married her, too.

Silly, isn't it? But, it does point out the rich rewards awaiting those who try Dollinger Staynew Filters. They're available for practically any filtration job; and you can select any filtering material for whatever degree filtration you desire. Let us know your requirements. Dollinger engineers will gladly make recommendations.

STAYNEW MODEL CPHS PIPE LINE FILTER

has the exclusive "double action principle." Air is first deflected to outer walls of Filters and forced downward at high speed. Water, oil, and heavier particles of rust, etc. are thus deposited in base. Mechanically cleaned air then rises to pass through filtering medium which removes lighter airborne particles. This "double action" design eliminates need for frequent cleaning.

Inexpensive, simple to install, Dollinger Pipe Line Filters pay for themselves in reduced maintenance alone. Why not talk over your filtration problems with a Dollinger engineer . . . or write for Bulletin 200 which gives engineering data on pipe line filters. Dollinger Corporation 47 Centre Park, Rochester 3, N. Y.

PROTECTOMOTOR

STAYNEW FILTERS

DOLLINGER

SPECIALIZING IN DRY TYPE FILTERS FOR OVER 35 YEARS

LIQUID FILTERS • PIPE LINE FILTERS • INTAKE FILTERS • HYDRAULIC FILTERS • ELECTROSTATIC FILTERS • MIST COLLECTORS • DRY PANEL FILTERS • SPECIAL DESIGN FILTERS • VISCOUS PANEL FILTERS • LOW PRESSURE FILTERS HIGH PRESSURE FILTERS • AUTOMATIC VENTILATION FILTERS • NATURAL GAS FILTERS • SILENCER FILTERS

For more data on advertised products, use Readers' Service Cards, last page.

what's your plant water problem?

■ CONSULTANTS ON INDUSTRIAL WATER PROBLEMS

BETZ LABORATORIES, INC., Philadelphia 24, Pa.

IMMEDIATE DELIVERY...

ESCO IPS SCREWED FITTINGS

CAST STAINLESS STEEL

150 LB. STANDARD

ESCO cast stainless fittings are a vital part of every corrosion resistant piping system. Cast with heavy wall sections and in a variety of analyses, *ESCO* screwed fittings are carried in warehouse stocks in sizes ranging from ⅛" to 4". Complete size range is available in 90 and 45 degree elbows, tees, crosses, unions, couplings, reducers, plugs, bushings and locknuts. Permanent alloy identification is cast in each fitting to eliminate replacement error.

Special sizes, types and alloys can be made to engineering specifications.

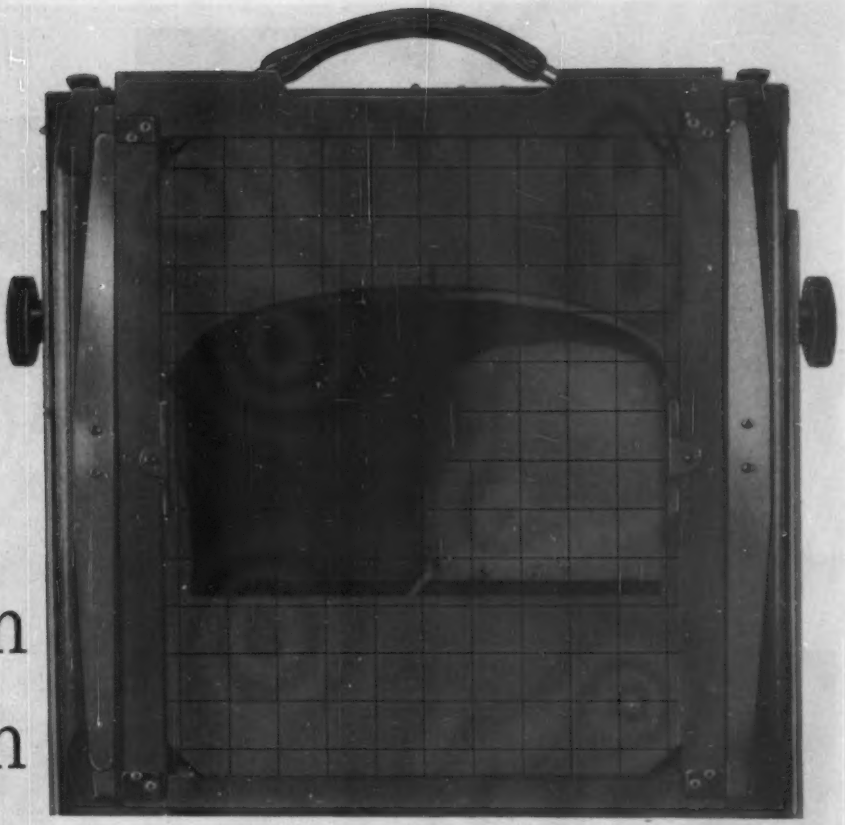
ESCO cast stainless fittings are available from convenient warehouse stocks. See your nearest *ESCO* dealer. He can help you solve your corrosion problems. Ask for *ESCO* Catalog No. 156 giving complete dimensional data.

ESCO

ELECTRIC STEEL FOUNDRY COMPANY

2164 N. W. 25TH AVE. • PORTLAND 10, OREGON
MFG. PLANTS AT PORTLAND, ORE. AND DANVILLE, ILL.
Offices in Most Principal Cities
ESCO INTERNATIONAL, NEW YORK, N. Y.
IN CANADA ESCO LIMITED

For more data on advertised products, use Readers' Service Cards, last page.



keep gum formation out of the picture with... Tenamene

EASTMAN GASOLINE ADDITIVES

Protect gasoline in storage against power-robbing gum formation with Tenamene additives.

The Tenamene line includes every principal type of gum inhibitor in commercial use today.

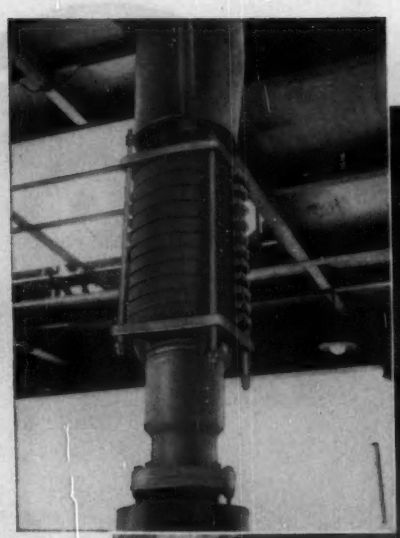
The quality and uniformity of the Tenamene additives are assured since Eastman manufactures all of the gasoline additives it supplies and exercises precise control over every step in the manufacture of them.

On-the-spot technical service is available from qualified Eastman petroleum specialists to help you achieve maximum performance from these dependable additives.

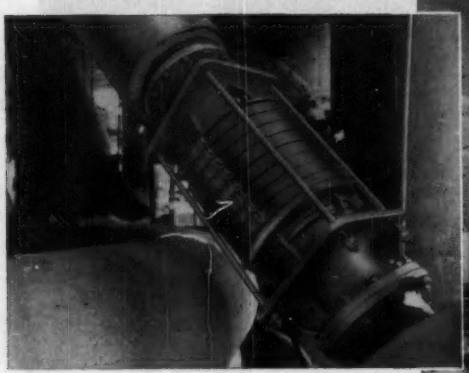
For more information on Tenamene additives and the service that backs up their proper use, contact our local representative or write to EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

SALES OFFICES: **Eastman Chemical Products, Inc.,** Kingsport, Tennessee; New York City; Framingham, Mass.; Cincinnati; Cleveland; Chicago; St. Louis; Houston. **West Coast: Wilson Meyer Co.,** San Francisco; Los Angeles; Portland; Salt Lake City; Seattle; Denver; Spokane; Phoenix.

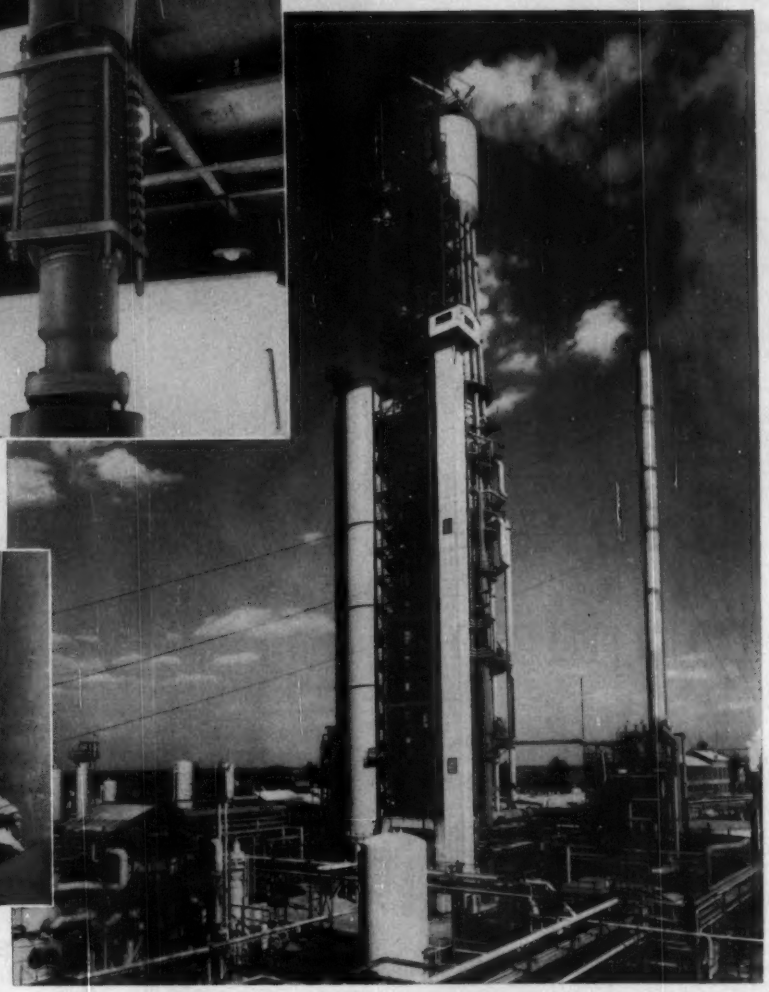
For more data on advertised products, use Readers' Service Cards, last page.



ADSCO Corruflex Expansion Joint with #316 stainless steel element. From the position of the tie-rods, note the pipe movement the joint is absorbing.



In this section of the Houdriflow unit, there are 12 ADSCO Corruflex Expansion Joints with #316 stainless steel elements. Temperature here is 1100°F.



Houdriflow Catalytic Cracking Unit, Marcus Hook Refinery, Sun Oil Co.

LET THE PIPES SQUIRM . . .

ADSCO
EXPANSION JOINTS
are on the job

Here, at the Marcus Hook Refinery of Sun Oil Co., temperatures run high. The piping naturally moves around a bit. But Sun engineers don't worry because they installed 62 ADSCO Corruflex Expansion Joints to take the movement. Lateral offset, angular rotation, off-tackle slants . . . name it and ADSCO Expansion Joints can absorb it. If you expect your pipes will get frisky, call the nearest ADSCO sales-engineer. He'll know what to do.

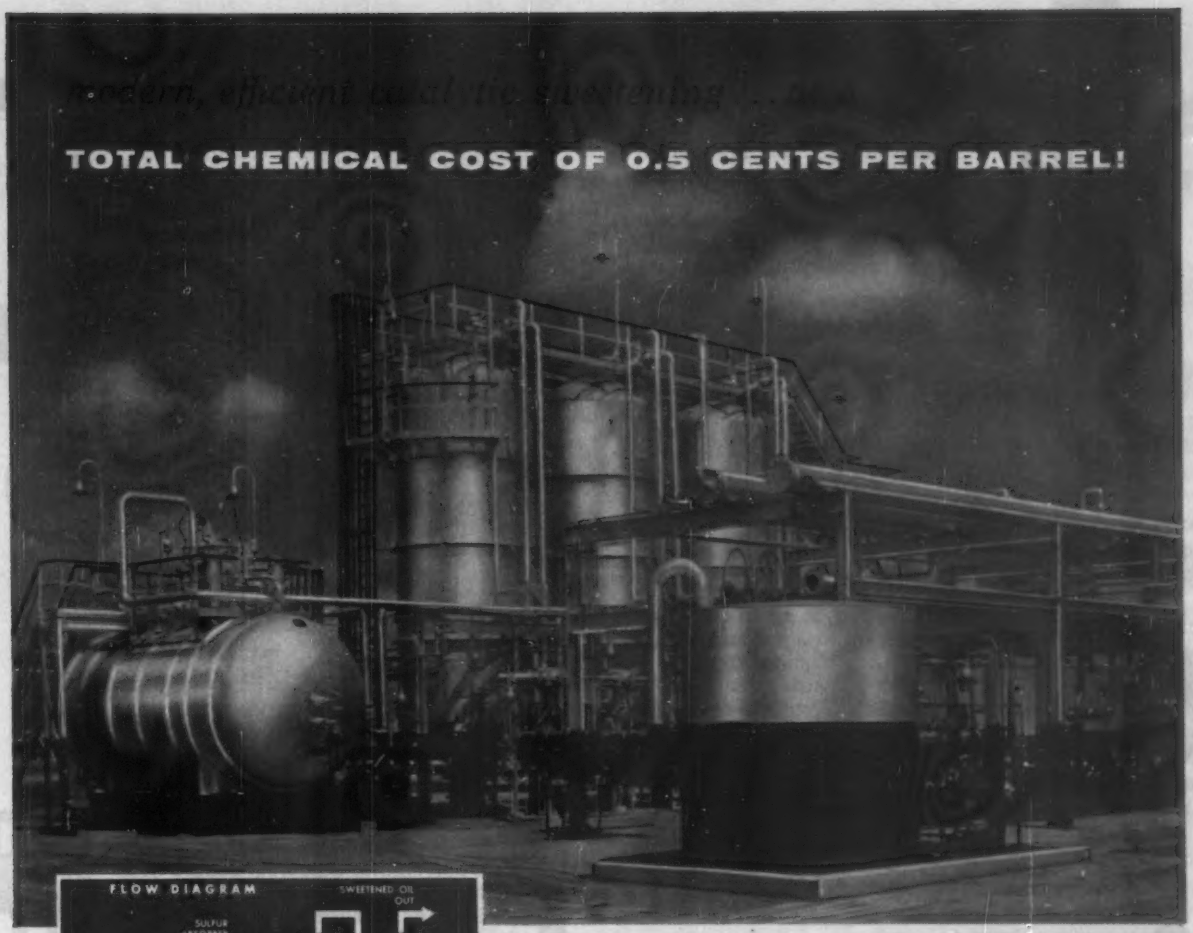
ADSCO DIVISION
20 MILBURN STREET
BUFFALO 12, NEW YORK

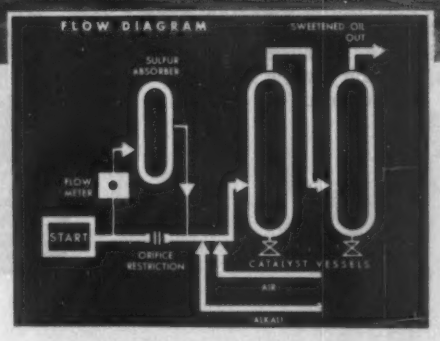
Member, Expansion Joint Manufacturers Association

YUBA

YUBA CONSOLIDATED INDUSTRIES, INC.

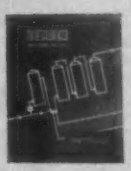
For more data on advertised products, use Readers' Service Cards, last page.





how Petreco-Bender Catalytic Sweetening Works:

Controlled quantities of sulfur, alkali and air are added to the product stream. The resulting mixture is passed through a catalyst bed. The process sweetens by converting mercaptans to disulfides by oxidation—in an automatic, continuous operation.



Illustrated Bulletin . . . yours on request

PETRECO-BENDER

catalytic sweetening process

It's true. The effective sweetening of distillates in the gasoline, kerosine, burning oil range can be accomplished the Petreco-Bender way for about half a cent a barrel—for all chemical costs, including catalyst maintenance. (Installation cost also is low, ranging from $10 to $20 per barrel/day of throughput.)

Beyond these obvious cost advantages, the Petreco-Bender process is simple to operate and maintain.

THERE ARE OTHER ECONOMIES, TOO!

- Automatic control . . . minimal operating attention.
- Long catalyst life . . . simple on-the-site reactivation.
- No product loss.
- Freedom from copper contamination.
- Sweet, non-corrosive product.
- No stream or air pollution.

PETRECO

A DIVISION OF PETROLITE CORPORATION

3202 So. Wayside Drive, Houston 1, Texas
1390 E. Burnett Street, Long Beach 7, California

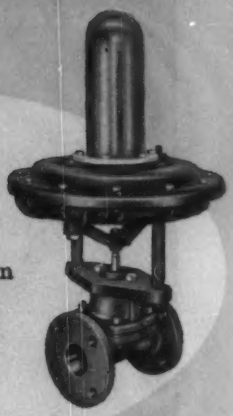
Specialized Petroleum Treating Processes and Equipment DESALTING • DEHYDRATING • DISTILLATE TREATING SWEETENING • LUBE OIL TREATING • SEDIMENT REMOVAL

D-58-1

Needle Valves

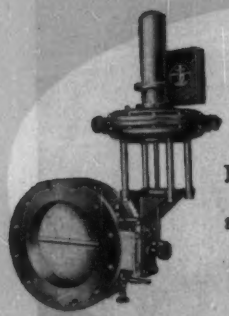
Rugged, outstanding performers for proportional control of small flows. Interchangeable seat rings and plugs. For water, gas, steam, chemicals. Trim and body materials available for "difficult" fluids. Shown here with unique *reversible* Stabilflo Motor.

GET THE BEST



Saunders Type Valves

A complete line, particularly suited to handling of highly corrosive fluids, or fluids containing solids in suspension. Available with Stabilflo Motor as shown, or with Stabiload Cylinder and Power Positioner.

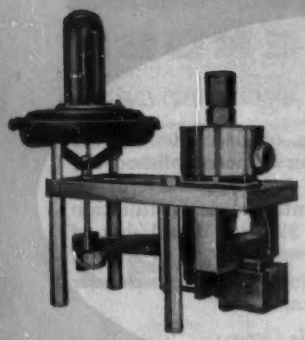


Butterfly Valves

Light and heavy duty types, with angle or swing-through seating, in spool or wafer body style, for low pressure air, gases in combustion control, steam, high pressure gases and liquids, etc. Available with Stabilflo Motor (shown) or cylinder operator.

Gate Valves

Guillotine-type slide valves, specially designed to handle pulp fibre, slurries, and similar fluids. Available with Stabiload Cylinder and Power Positioner as illustrated, for throttling service, or with 4-way pilot valve for on-off service.



Super-Pressure Valves

For throttling or let-down service up to 30,000 psi. Features an exclusive high-pressure bellows seal. Port sizes and connections to meet high pressure process specifications.

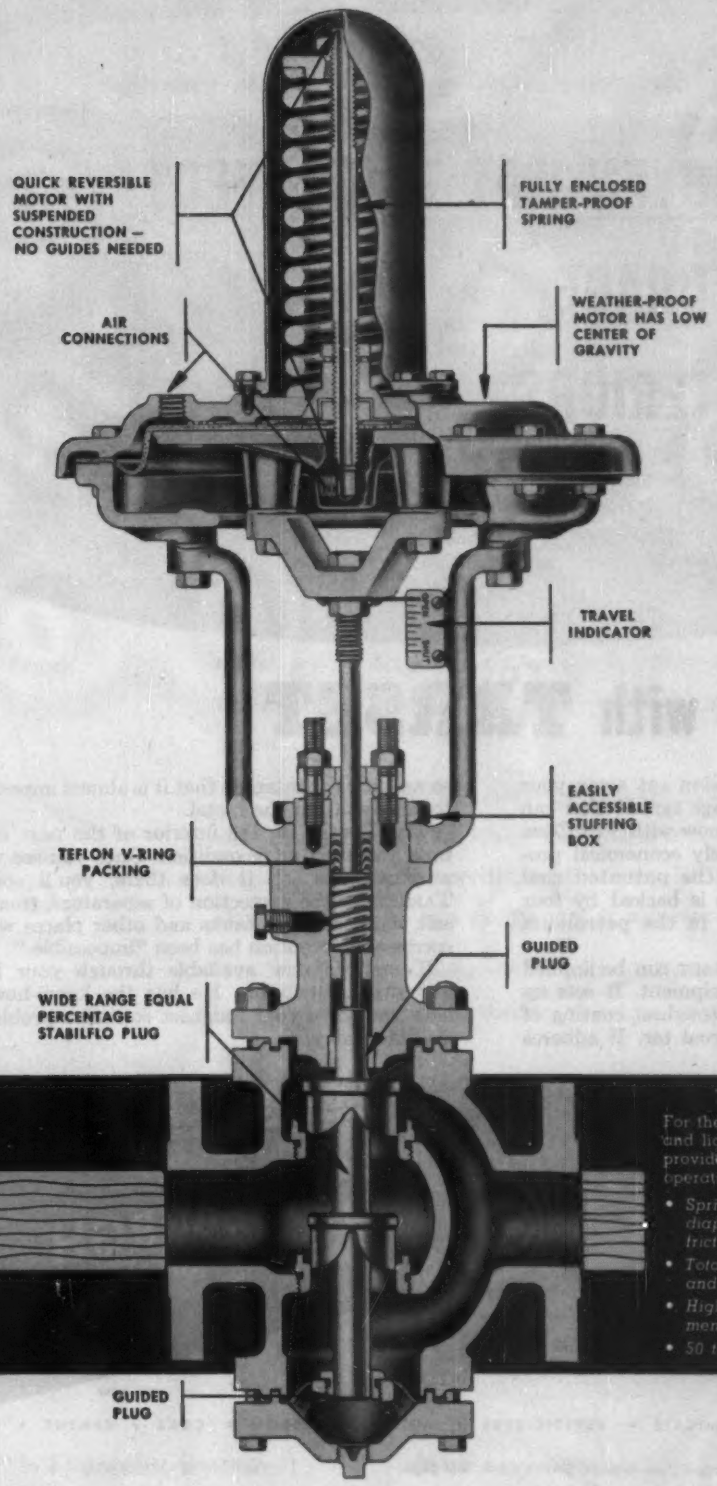
FOXBORO CONTROL VALVES

Reg. U.S. Pat. Off.

9 Strategic Branch Shops for Coast-to-Coast Service: Atlanta, Ga. • Pittsburgh, Pa. • Chicago (Skokie), Ill. • Dallas, Tex. • Houston, Tex. • San Francisco (San Leandro), Cal. • Los Angeles, Cal. • Montreal, Que. • Vancouver, B. C.

SOLUTION TO YOUR CONTROL VALVE PROBLEMS

...with Foxboro Pneumatic Control Valves


QUICK REVERSIBLE MOTOR WITH SUSPENDED CONSTRUCTION — NO GUIDES NEEDED
FULLY ENCLOSED TAMPER-PROOF SPRING
AIR CONNECTIONS
WEATHER-PROOF MOTOR HAS LOW CENTER OF GRAVITY
TRAVEL INDICATOR
EASILY ACCESSIBLE STUFFING BOX
TEFLON V-RING PACKING
GUIDED PLUG
WIDE RANGE EQUAL PERCENTAGE STABILFLO PLUG
GUIDED PLUG

You can always be sure of getting the control valve best suited to flow conditions and control actions when you specify Foxboro. No other single source offers such a wide variety of control valves for specific applications. None other has Foxboro's experience in applying them — in every phase of industrial processing.

Your choice extends from valves for simple on-off control at one extreme, to specialized proportioning control at the other; for high vacuum work to operation at 30,000 psi; for temperatures from −350° to +1000°F. And there's a wide choice of plug designs — and of alloys and trim to handle even severely corrosive and erosive fluids.

You can save shipping cost and time, too, buying direct from Foxboro's strategically located branch shops. They're staffed by experts.

A few typical control valves from Foxboro's complete line are illustrated here. For full details, or specific information on your problem, call your nearby Foxboro Field Engineer or write The Foxboro Company, 746 Neponset Ave., Foxboro, Mass.

STABILFLO CONTROL VALVES

For the great majority of temperature, pressure, flow, and liquid level control applications, this basic valve provides unsurpassed sensitivity and troublefree operation. Unique design features:

- *Spring-above-diaphragm construction makes diaphragm motor self-aligning, virtually free from friction and hysteresis.*
- *Totally enclosed spring protects against tampering and corrosion.*
- *High-lift wide range V-port provides greater increment of lift for given change in air pressure.*
- *50 to 1 rangeability, equal percentage characteristics.*

with TARSET®

DON'T let crude oil corrosion eat away your investment in costly storage tanks! You can control these corrosion losses now with *Pitt Chem* TARSET, a *proven* and relatively economical protective coating. TARSET is the patented coal tar-epoxy resin coating which is backed by four years of service experience in the petroleum industry.

A cold-applied coating, TARSET can be applied with conventional coating equipment. It sets up quickly to form the hardest, toughest coating of its kind ever produced from coal tar. It adheres so well to tank interiors that it is almost impossible to remove from the metal.

Try TARSET on the interior of the next crude tank *you* erect or recondition. Once you see what a remarkable job it does there, you'll specify TARSET for the protection of separators, treaters, salt water disposal tanks and other places where corrosion prevention has been "impossible."

TARSET is now available through your local industrial distributor. He has the know-how to help you solve your toughest corrosion problems. *Call him today!*

Think First of the Coatings that Last!

★ **PITT CHEM**
Coal Tar Coatings

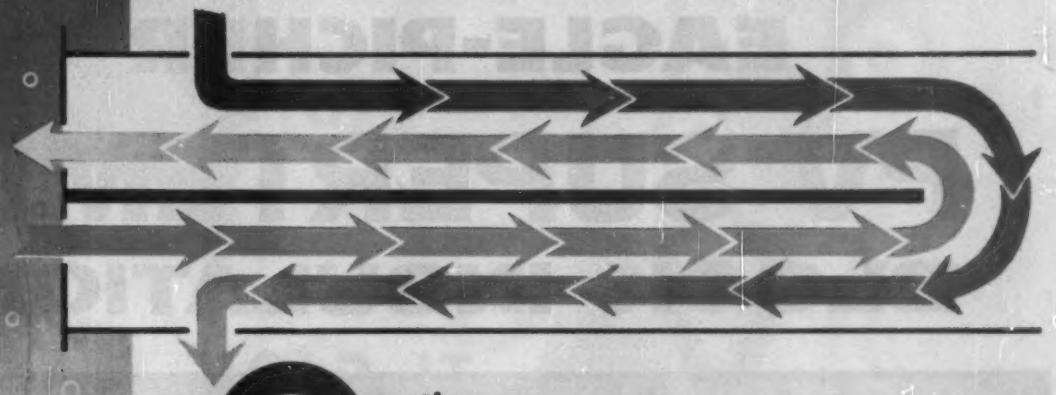
★ **PITT CHEM**
"Insul-Mastic" Gilsonite Coatings

★ **PITT CHEM**
"Tarset" Coal Tar-Epoxy Resin Coating

PITT CHEM Industrial Coatings are available through leading Industrial Distributors. See the "Yellow Pages."

PROTECTIVE COATINGS • COAL CHEMICALS • PLASTICIZERS • ACTIVATED CARBON • COKE • CEMENT • PIG IRON

Is multi-pass shell construction practical in heat exchanger design?



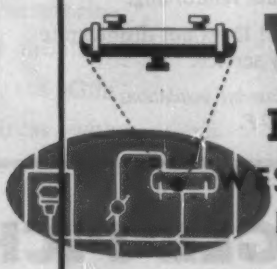
Question:
Are the design features of multi-pass shell construction sound and applicable for process heat exchangers?

Answer:
Yes, *if properly designed and applied*, multi-pass shell heat exchangers effect substantial savings in initial installation costs. Western has been successful with multi-pass shell construction because . . .

. . . of a thorough knowledge of the applications for which each Western heat exchanger is designed. Consequently, Western two-pass shell exchangers are recommended and specified only for those applications where they are ideally suited.

Western multi-pass shell exchangers have achieved satisfactory service for our customers at far lower investment cost. By reducing the number of shells required to handle specific applications, the Western multi-pass shell exchanger does the work of two exchangers at substantially lower initial cost.

A Western representative will gladly advise you as to the possibility of applying two-pass shell construction to your next heat transfer requirements.



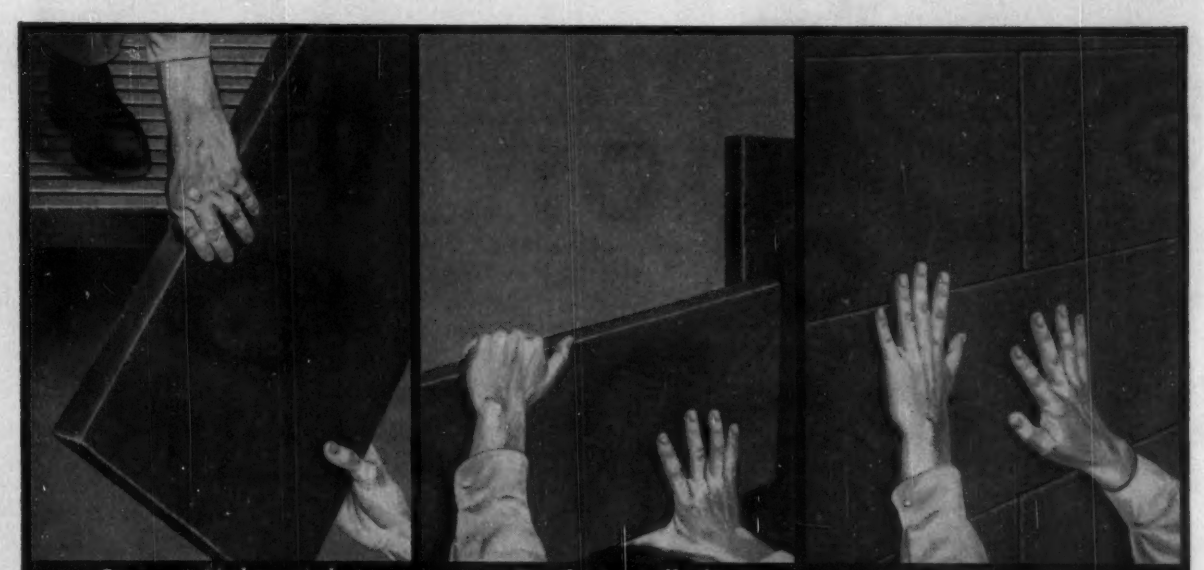
WESTERN
HEAT EXCHANGERS
WESTERN SUPPLY COMPANY
P.O. Box 1888 – Tulsa, Oklahoma

For more data on advertised products, use Readers' Service Cards, last page.

A TRUE-CUT BLOCK WITH PRECISION-FINISH!

EAGLE-PICHER

PV SUPERTEMP
BLOCK INSULATION



Strong, Lightweight! *Easily Installed!* *Precision Finish!*

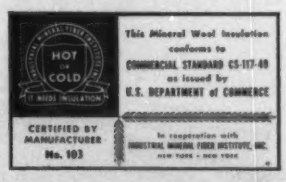
- Eagle-Picher's "precision-finish" is one of the most important insulation developments in years.
- Highly efficient, all-purpose block that is practically dustless.
- Great structural strength! Meets rigid demands for long-lasting block able to withstand wide temperature range up to 1900 F.
- Lightweight, easily installed! Easily cut to fit irregular areas—no special tools needed. Requires only minimum reinforcing.
- Effectively resists steam and other moisture! Does not disintegrate or lose thermal efficiency under heavy duty service.

Eagle-Picher produces a complete line of industrial insulations for all temperatures from below Zero to over 2000 F.

FREE SAMPLE!

Write Today!

Eagle-Picher PV Supertemp Block conforms to Commercial Standard CS 117.



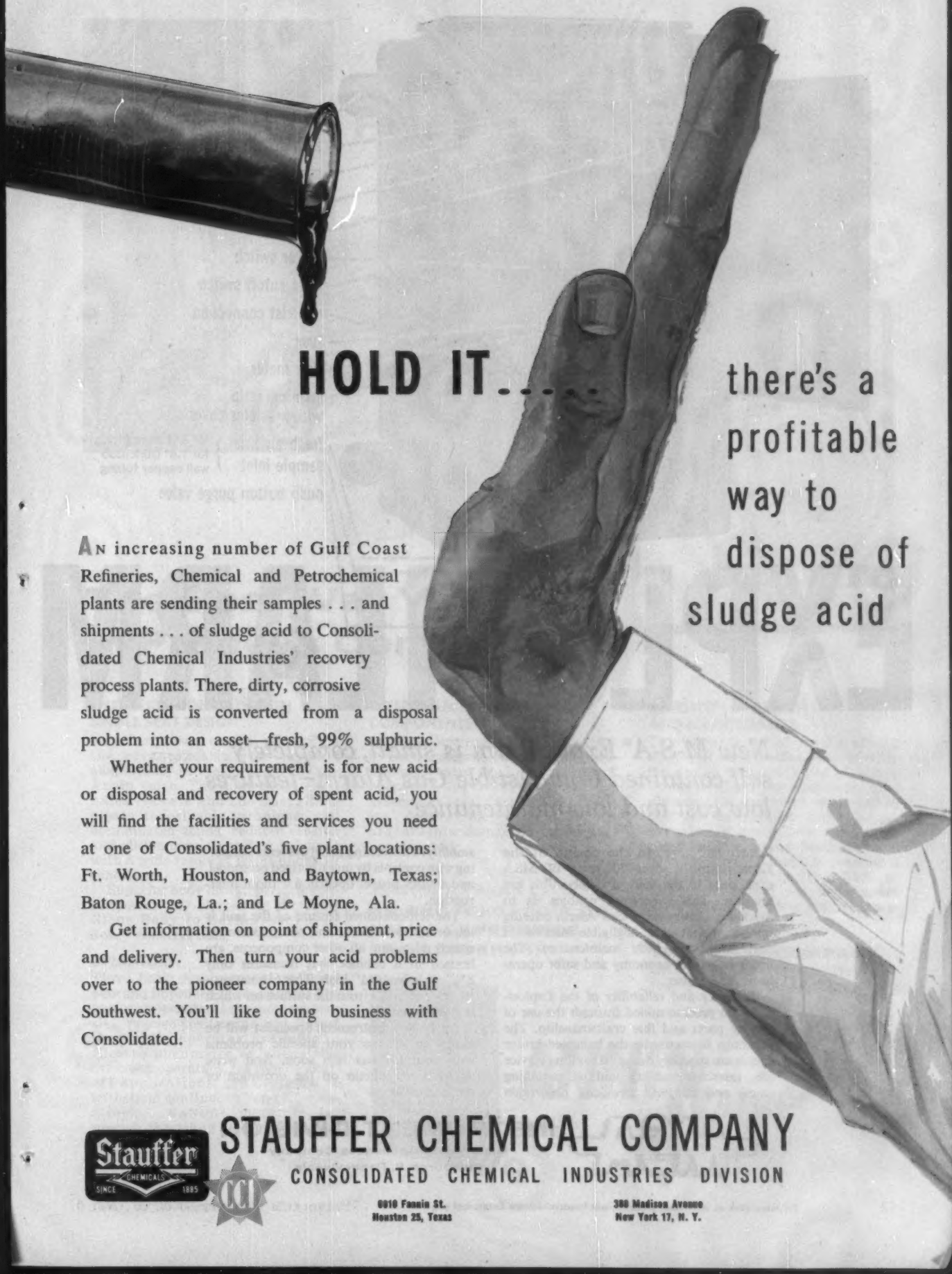
Since 1843

EAGLE EP PICHER

EAGLE-PICHER

The Eagle-Picher Company • General Offices: Cincinnati 1, Ohio

(Member of Industrial Mineral Fiber Institute)



HOLD IT.... there's a profitable way to dispose of sludge acid

AN increasing number of Gulf Coast Refineries, Chemical and Petrochemical plants are sending their samples . . . and shipments . . . of sludge acid to Consolidated Chemical Industries' recovery process plants. There, dirty, corrosive sludge acid is converted from a disposal problem into an asset—fresh, 99% sulphuric.

Whether your requirement is for new acid or disposal and recovery of spent acid, you will find the facilities and services you need at one of Consolidated's five plant locations: Ft. Worth, Houston, and Baytown, Texas; Baton Rouge, La.; and Le Moyne, Ala.

Get information on point of shipment, price and delivery. Then turn your acid problems over to the pioneer company in the Gulf Southwest. You'll like doing business with Consolidated.

Stauffer CHEMICALS SINCE 1885

CCI

STAUFFER CHEMICAL COMPANY

CONSOLIDATED CHEMICAL INDUSTRIES DIVISION

6910 Fannin St.
Houston 25, Texas

380 Madison Avenue
New York 17, N. Y.

EXPLOSILARM

New M-S-A® Explosilarm is small, completely self-contained Combustible Gas Alarm—features low cost and low maintenance

Employed here, in the design of the Explosilarm, is over 30 years of MSA experience in the field of combustible gas analysis. This experience enables us to market a Combustible Gas Alarm offering minimum first cost, negligible installation cost, and very little maintenance. The result is greater economy and safer operations for the user.

Accuracy and reliability of the Explosilarm are predetermined through the use of quality parts and fine craftsmanship. The platinum filaments in the balanced-bridge circuit are specially designed for long service life, interchangeability without matching pairs, and *extreme zero and calibration stability*. The locking panel prevents tampering with controls by unauthorized personnel, and assures proper operation without interruption.

The self-contained feature of the unit is important too. Motor and pump assembly, meter, relay, and all other components, are housed in a cabinet that measures only 8¾" wide by 14¼" high. This cabinet protrudes only 6¼" from the surface on which it is mounted.

An M-S-A Instrument Specialist will be happy to discuss your specific problems with you. Contact him soon. And write us for new bulletin on the operation of the Explosilarm.

MSA

INSTRUMENT DIVISION

Mine Safety Appliances Company
Pittsburgh 8, Pennsylvania

For more data on advertised products, use Readers' Service Cards, last page.

HOW ANNIN DOES IT.

The Best Way Yet in Process Control

SPLIT BODY CONSTRUCTION... SINGLE SEAT DESIGN

No other process control valve offers the advantages in economy and adaptability as that provided by the Annin valve. The split body eliminates pockets and shoulders that create undesirable turbulence and accumulated solids, reduces erosion and allows consistent flow behavior with a wide range of fluids under all conditions.

Superior body design permits conversion in any alloy from the basic Globe Body to Corner, Angle or 3-way construction.

OPERATORS

Three basic Annin operators bring new and improved performance. The DOMOTOR operator is the most responsive, precise positioning and fastest pneumatic operator available... Electro-pneumatic or pneumatic CYLINDER operators, for remote shut-off applications, are designed to withstand continuous "on-off" operations... MANUAL operators, for precise throttling of flow rate and tight closure.

INTERCHANGEABILITY OF COMPONENTS

Applications unlimited are provided by interchangeability of Annin component features. Three types of operators, and five types of packing assemblies (plain extension, bellows seal, doolseal, cooling fin and standard) are interchangeable on one yoke and one body.

SEND FOR THE ANNIN CATALOG—
AN ENCYCLOPEDIA OF VALVE EXPERIENCE AND LEADERSHIP

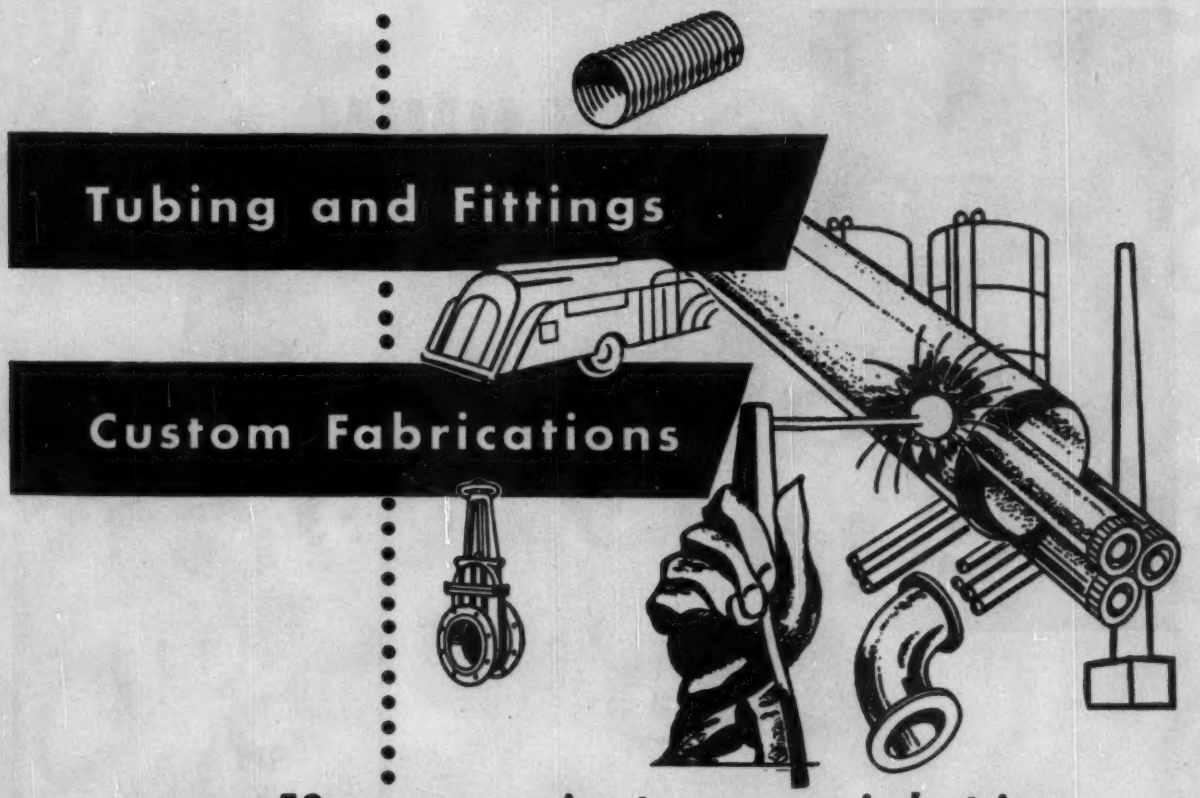
SIMPLICITY IN DESIGN AND MAINTENANCE

The advantages of Annin single seat, split valve bodies, coupled with the design characteristics of Annin Domotor and other operators, provide control engineers with valves that can be installed without compromise in materials, response, tight closure, piping flexibility and dependability... making possible a reduction of parts from 50% to 75%, lower initial cost, lower spare parts inventory, lower maintenance.

THE ANNIN COMPANY
Division of The Annin Corporation
1040 S. Vail Ave., Montebello, California

ANNIN VALVES

For more data on advertised products, use Readers' Service Cards, last page.



over 50 years service to process industries . . .

CUSTOM FABRICATIONS:

TO MEET YOUR SPECIFIC REQUIREMENTS — Quality fabrication of stainless steel, stainless clad, monel, inconel, copper, aluminum, hastelloy, carpenter 20 and hot rolled mild steel.

A complete line of stainless steel and alloy tubing and fittings furnished to your exact specifications and drawings for economical field installation.

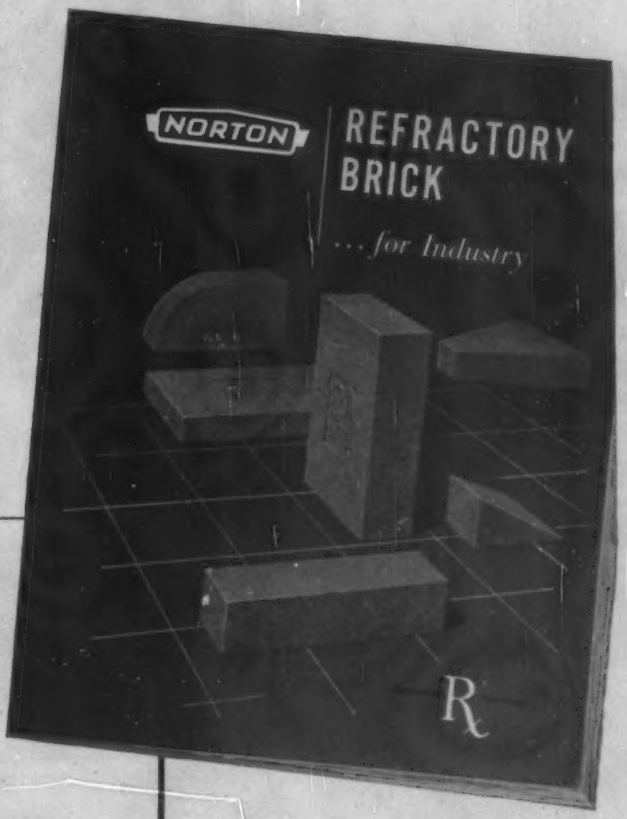
Skill and experience have earned Felker Bros. the reputation for leadership with the process industries for dependable and quality fabrication. We offer a specialized service in the fabrication of alloys.

FELKER BROTHERS MANUFACTURING CO.

PHONES 230-231 MARSHFIELD, WIS.

Send for this

New Booklet to Help Improve Your High Temperature Processing



Covers Norton refractory brick applications, characteristics, chemical analyses — includes helpful data on materials of construction for temperatures up to 4,400°F.

This new, 24-page Norton booklet can be a dependable guidebook for your selection of the refractories you need to improve production and cut costs in high temperature processing.

Eight Norton-developed refractory materials are covered: ALUNDUM* "T" 87% Alumina; ALUNDUM "A" 99% Alumina; ALUNDUM "L" 99% Insulating Alumina; CRYSTOLON* "G" Silicon Carbide; CRYSTOLON "N" Nitride Bonded Silicon Carbide; MAGNORITE* "K" Fused Magnesia; Zirconia "H" Dense Zirconia; Zirconia "I" Insulating Zirconia.

All essential details are listed, such as: how each material is produced . . . important properties, characteristics and chemical analyses . . . shapes of brick and other molded products that are available . . . representative applications . . . packing methods that assure safe arrival.

Also included are charts and tables of brick shapes and sizes, thermal expansion and conductivity graphs, and a temperature conversion chart.

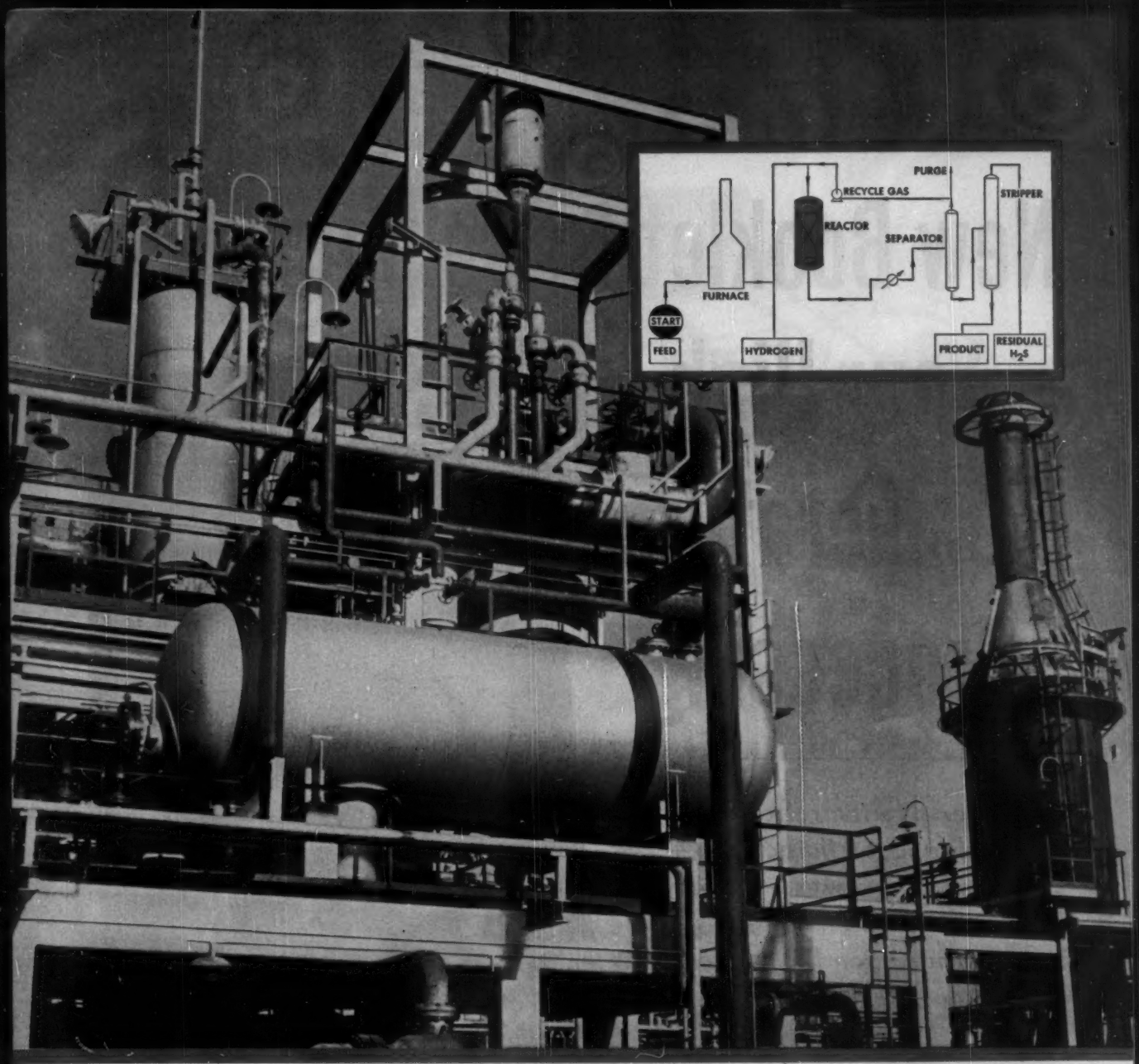
Norton refractories — engineered and prescribed for the widest range of applications — have helped many users save time and money. The ℞'s described in *"Norton Refractory Brick . . . for Industry"* may do the same for you. Write for your copy to NORTON COMPANY, Refractories Division, 465 New Bond Street, Worcester 6, Massachusetts.

NORTON
REFRACTORIES
Engineered... ℞ ...Prescribed
Making better products . . . to make your products better

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

NORTON PRODUCTS Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electrochemicals — BEAR-MANNING DIVISION Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

For more data on advertised products, use Readers' Service Cards, last page.



19,500 B/D CRACKED HEATING OIL HYDROFINER, ESSO STANDARD'S BAYWAY REFINERY, LINDEN, N. J.

HYDROFINING CAN GIVE YOU TOP PERFORMANCE AT LOWEST INVESTMENT

Esso Research and Engineering offers you *Hydrofining*, a process now being applied to a greater variety of feed than any other hydrogen-treating process. *Hydrofining* uses by-product hydrogen to remove sulfur and other impurities *without yield loss.*

The process improves product stability, odor, color and other quality characteristics without the disadvantages of chemical or clay treating methods. *Hydrofining* is another achievement of the Esso Research program — 39 years of new process developments made available to refiners around the world.

Hydrofining experience has been gained from commercial units processing a wide variety of feed stocks such as naphthas, distillate fuels, lubes and waxes. This experience plus years of hydrogenation research gives us a unique opportunity to recommend the best design for your plant.

Twenty-three *Hydrofining* installations are on stream; nineteen more are in the construction or planning stage. Licensees enjoy benefits of continuing *Hydrofining* research. *Hydrofining* can play an important part in helping you process previously unattractive stocks into higher quality products. We would welcome your inquiry.

ESSO RESEARCH AND ENGINEERING COMPANY

P.O. Box 243, Elizabeth B, N. J.

Your key to progress... an Esso Research process

Is your future on paper now?

YOUR FUTURE BEGINS with an arc and a line, with dimensions and specifications. How your future *extends* from these plans on paper depends largely on the skills and facilities of the men who build from these masterful markings.

One thing is sure. For your petrochemical processing equipment, you *can* depend on the skills and facilities of Bros Incorporated—steel plate fabricators for the nation since 1882.

Fractionating towers, pressure vessels, autoclaves, stacks and storage tanks—these are some of the special fabrications of large and small capacities that Bros builds. All in a long tradition of exact conformance to prints and specifications.

And, if you need expert assistance in the planning and design of your process equipment, the Bros team of 350 engineers, designers and specialists in steel plate fabrication are yours to command.

Bros has modern shop facilities for welding and working steel plate up to 2" thick. Fabrications conform to all accepted code requirements. X-ray and annealing facilities, too, are available.

When required, skilled Bros field crews go where needed to erect units too large for such limiting conditions as shop and shipping clearances.

Today more and more industries are looking to Bros for their steel plate fabrication needs. So if your future is on paper, now is the time to bring Bros into the picture.

Bros also manufactures package and field erected boilers and stokers to supply all your steam generation requirements.

Call your BROS *sales engineer today!*

BROS NATIONAL DEALERS

BIRMINGHAM—Palmer & Lawrence
BISMARCK—Lignite Combustion Engineering Corp.
CHICAGO—D. H. Skeen and Company
DALLAS—Mechanical Specialty Co.
DENVER—The Lucas Engrg. Co.
DETROIT—Wayne Boiler & Equip. Co.
DULUTH—Williams-Swanson Co.
GRAND RAPIDS, MICH.—Clay C. Zuiderhoek
INDIANAPOLIS—Young-Streeter Co.
KANSAS CITY, MO.—D. E. Maskill Co.
LOS ANGELES—Frank M. Beeson
LOUISVILLE—H. E. Townsend
LYNCHBURG, VA.—The Campbell King Co.
NASHVILLE—Power Specialty Co.
NORWOOD, N. J.—Eastern Power Equip. Corp.
OMAHA—Pioneer Pipe & Supply Co.
RIPON, WIS.—Yates Equip. & Supply Co.
ROCHESTER, N. Y.—Automatic Combustion Equip. Co.
SALT LAKE CITY—James J. Burke Co.
SEATTLE—Superior Engineering Co.
TULSA—Bagwell Company

BROS *Incorporated*

General Sales Division

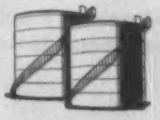
1057 TENTH AVE. S.E. • MINNEAPOLIS 14, MINNESOTA

BROS

PACKAGE BOILERS

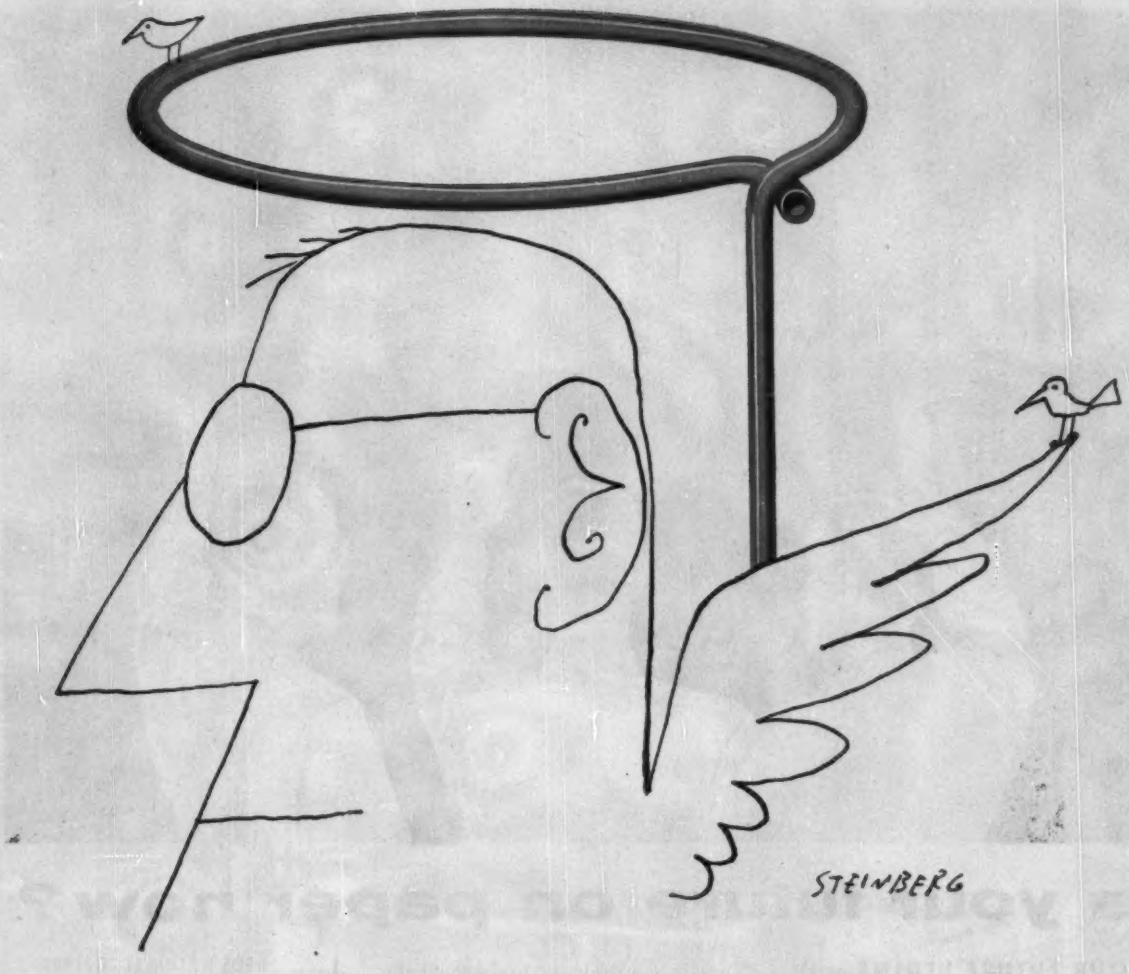
AUTOCLAVES

FRACTIONATING TOWERS



STORAGE TANKS

For more data on advertised products, use Readers' Service Cards, last page.



everlasting

How to beat Old Debbil Time . . .

We frustrate Time . . . by forming Lewin-Mathes Seamless Tube and Pipe out of *ageless Copper* . . . heavy-walled and durable . . . smelted to meticulous purity in our own refinery.

We take Time . . . as *integrated specialists*, to test and check and analyze each step in production—from raw material to finished product—to guarantee perfect, *enduring* quality.

We save you Time . . . through a nation-wide network of Service Offices and Mill Depots, linked by Teletype, to assure *on-schedule* deliveries.

The Time *you* take to specify Lewin-Mathes for your Copper Tube and Pipe applications will be to your *everlasting* credit—and satisfaction!

LEWIN MATHES

SAINT LOUIS, MISSOURI

COPPER AND BRASS TUBE PIPE AND ROD

DIVISION OF CERRO DE PASCO CORP.

For more data on advertised products, use Readers' Service Cards, last page.

Drastic reduction
of heat loss with
PABCO
PRECISION-MOLDED
CALTEMP
a Calcium Silicate
Insulation

When vapors or liquids are conveyed or held at temperatures up to 1900° F.—when equipment is operated to high heat levels—Pabco insulations cut heat losses to absolute minimums. "Precision-Molded" by a patented process, Pabco's Caltemp and 85% Magnesia pipe and block insulations control temperatures within close tolerances. For data on technical advantages, case histories, or engineering consultation, write . . . or call a Pabco insulation engineer.

INSULATION GUIDE

Temperature	Recommended Pabco Insulation		
to 550°	85% Magnesia pipe covering	block	cement
to 1200°	Caltemp pipe covering	block	cement
to 1500°	Prasco 15 C pipe covering	block	cement
to 1900°	Prasco 19 C	block	

PABCO

INDUSTRIAL INSULATIONS DIVISION
Fibreboard Paper Products Corporation
San Francisco 19 • Chicago 54
Houston 4 • New York 16 • Los Angeles

For more data on advertised products, use Readers' Service Cards, last page.

Photo taken at Delaware Refinery, Tidewater Oil Company

They keep the big cats roaring

The healthy roar of production from the big cat crackers is the measure of progress in refining and chemical technology. Teamwork between refiners and Cyanamid chemists helped to bring the development of one of the first synthetic fluid cracking catalysts and the first fully regenerative platinum reforming catalyst. Behind Cyanamid's service as a major catalyst producer are its unlimited resources as a major chemical producer.

Only Cyanamid's man with the golden rule can bring such vast chemical research and development facilities to the service of further refining progress.

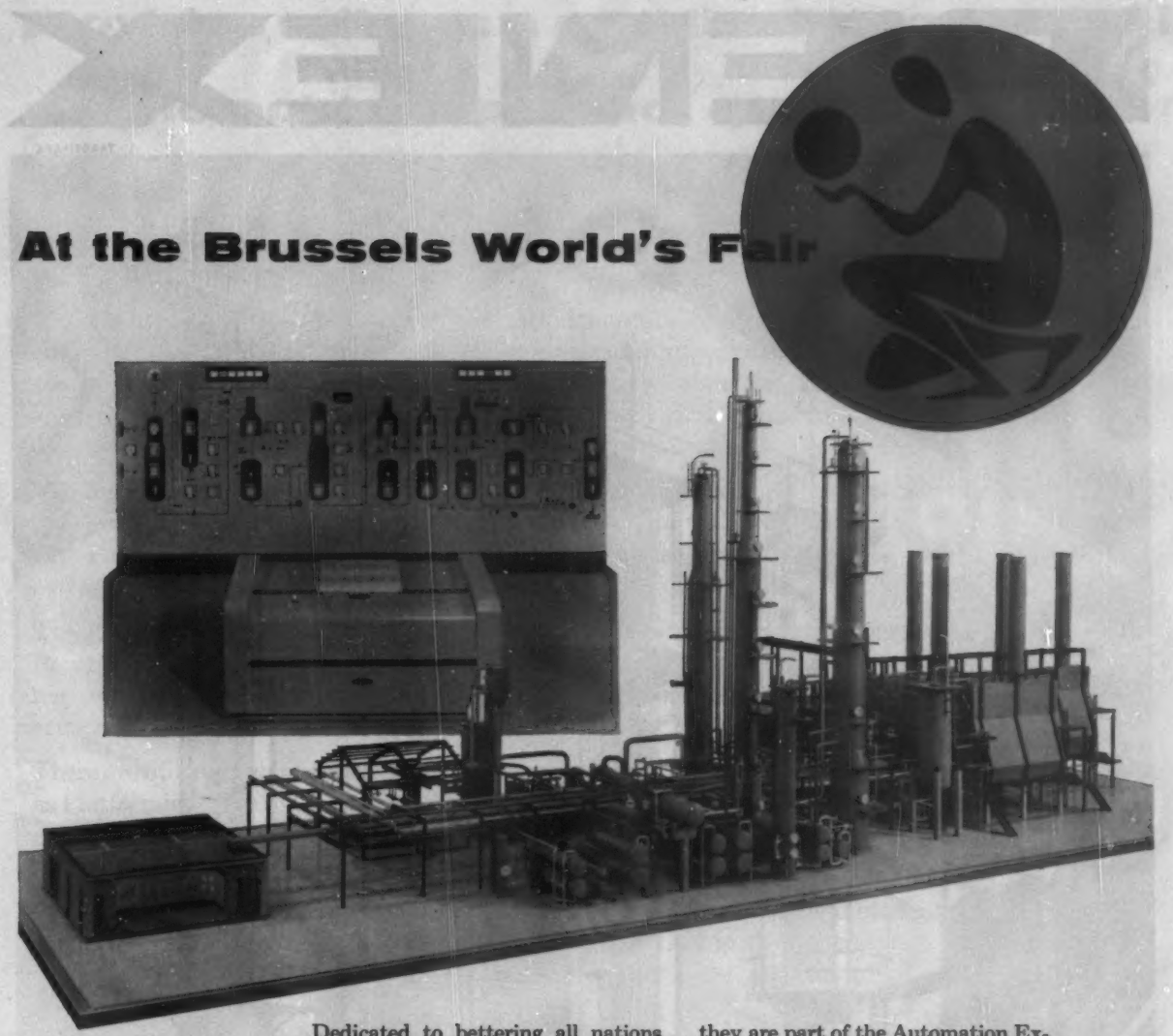
Basic in Catalyst Chemistry

CYANAMID

AMERICAN CYANAMID COMPANY • REFINERY CHEMICALS DEPARTMENT • 30 Rockefeller Plaza, New York 20, N. Y.

Originators of AEROCAT® Fluid Cracking Catalysts, AEROCAT TRIPLE A® High Alumina Catalysts, AEROFORM® Fluid Hydroforming and Platinum Reforming Catalysts, AERO® HDS Catalysts, AERO® Specialty Catalysts, CYPAN® Drilling Mud Conditioner, AEROLUBE® Lubricating Oil Additives, AERONOX® Antioxidants, AEROSOL® Surface Active Agents.

At the Brussels World's Fair



Dedicated to bettering all nations and peoples through better exchange of knowledge, the Brussels World's Fair provides a proper setting for the contributions made to mankind by petroleum and chemical engineering. Source of countless useful products, the petroleum and chemical industries have raised their own efficiency as well as world standards of living through technological progress. Typical are the advances made recently in automation.

This scale model of a Kellogg catalytic reformer and the replica of the Kellogg-designed control room demonstrate the trend to automatically controlled processing units. Together they are part of the Automation Exhibit at the United States Pavilion at Brussels. The scale model, built by Kellogg as a design tool for actual plant engineering and construction, was furnished by Kellogg. The graphic panel and data reduction console were built by Panellit, Inc.

These newest developments in a process and its control are being exhibited by the United States of America as examples of the technological accomplishments of free enterprise that benefit all mankind. Kellogg, proud of its part in them, is ready to serve all national economies with advanced engineering and construction services.

M KELLOGG W

The M. W. Kellogg Company

711 THIRD AVENUE, NEW YORK 17, N. Y.

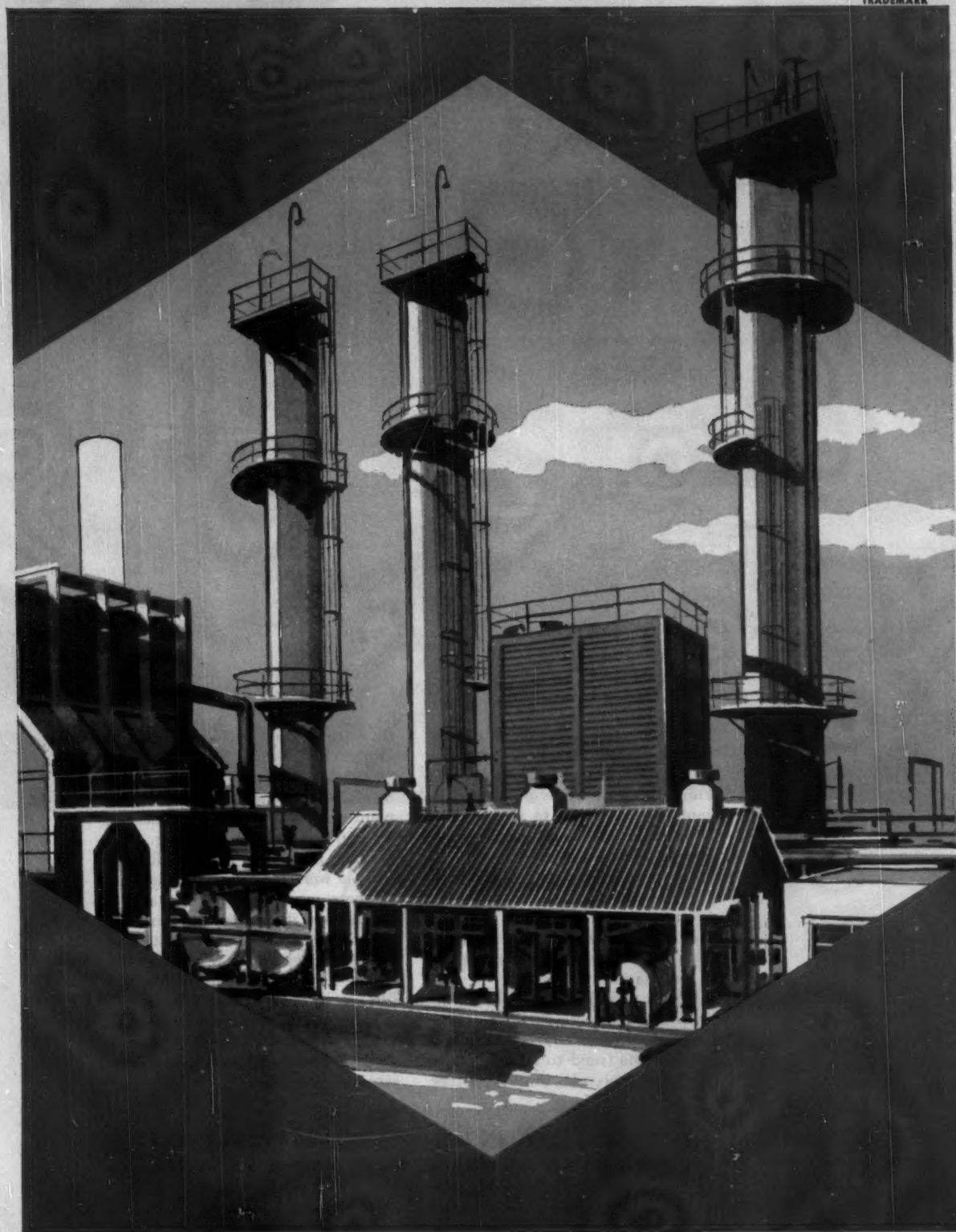
A SUBSIDIARY OF PULLMAN INCORPORATED

The Canadian Kellogg Company Ltd., Toronto • Kellogg International Corp., London • Kellogg Pan American Corp., New York
Societe Kellogg, Paris • Companhia Kellogg Brasileira, Rio de Janeiro • Compania Kellogg de Venezuela, Caracas

For more data on advertised products, use Readers' Service Cards, last page.

PENEX

TRADEMARK



provides refiners a practical, economical way to achieve product quality

UOP's new process converts light, normal paraffins to isoparaffins

Penex is the only commercial hydroisomerization process in operation. Here is how it works. Through the continuous catalytic isomerization of normal pentane and normal hexane in lower-value fuels, it produces a high octane isoparaffinic blending component. When blended with the fuel this component gives a finished product of higher octane value and superior combustion and carburetion qualities.

The Penex-produced finished product has high volatility, better burning qualities without plug-fouling and pre-ignition, better sensitivity and better lead susceptibility. The Penex method of increasing octane number with isoparaffins results in overall better-balanced, more efficient fuel.

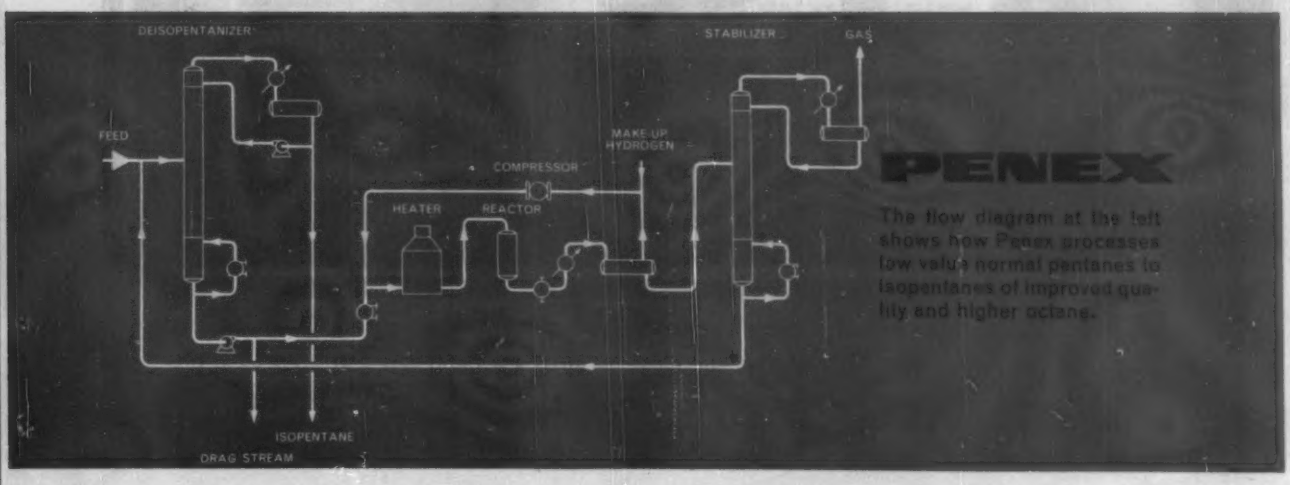
The Penex process is economical . . . in installation, in operation, in maintenance. Regeneration is not required, so capital investment cost is low, operation simplified and maintenance reduced. Catalyst and reaction products are non-corrosive, so lower-cost carbon steel construction can be used.

There are other economies, too. When Penex is used with a catalytic reforming process such as Platforming®, the make-up hydrogen is derived from the net high pressure separator gas. Hydrogen is consumed in insignificant quantities. This combination of processes also gives a considerable yield advantage at the same octane number.

Refiners interested in improving lower-value fuels, in octane number and efficiency, are invited to investigate thoroughly the application of PENEX to their operation.

UNIVERSAL OIL PRODUCTS COMPANY
30 Algonquin Road, Des Plaines, Illinois, U.S.A.

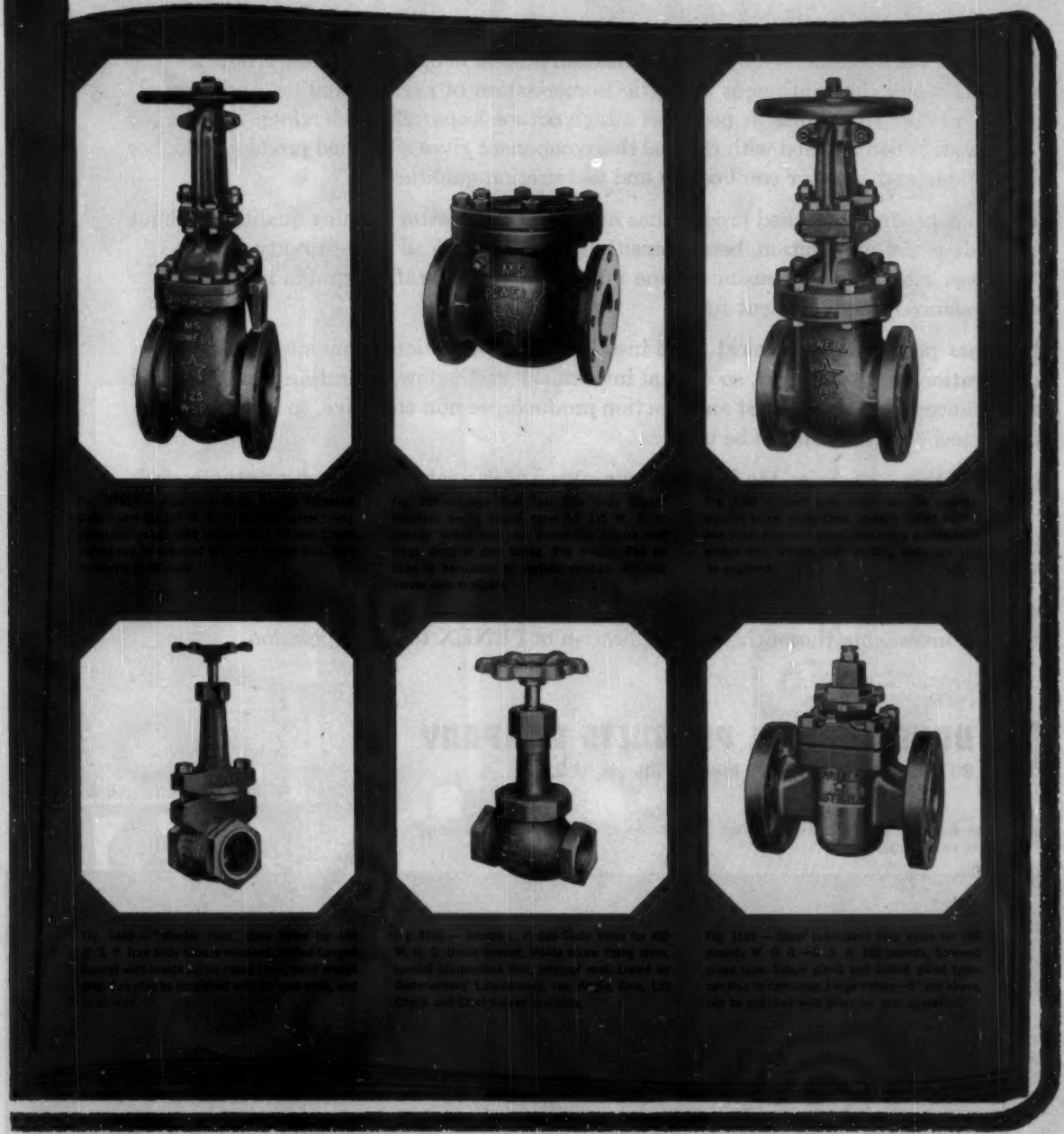
More Than Forty Years Of Leadership In Petroleum Refining Technology



For more data on advertised products, use Readers' Service Cards, last page.

POWELL

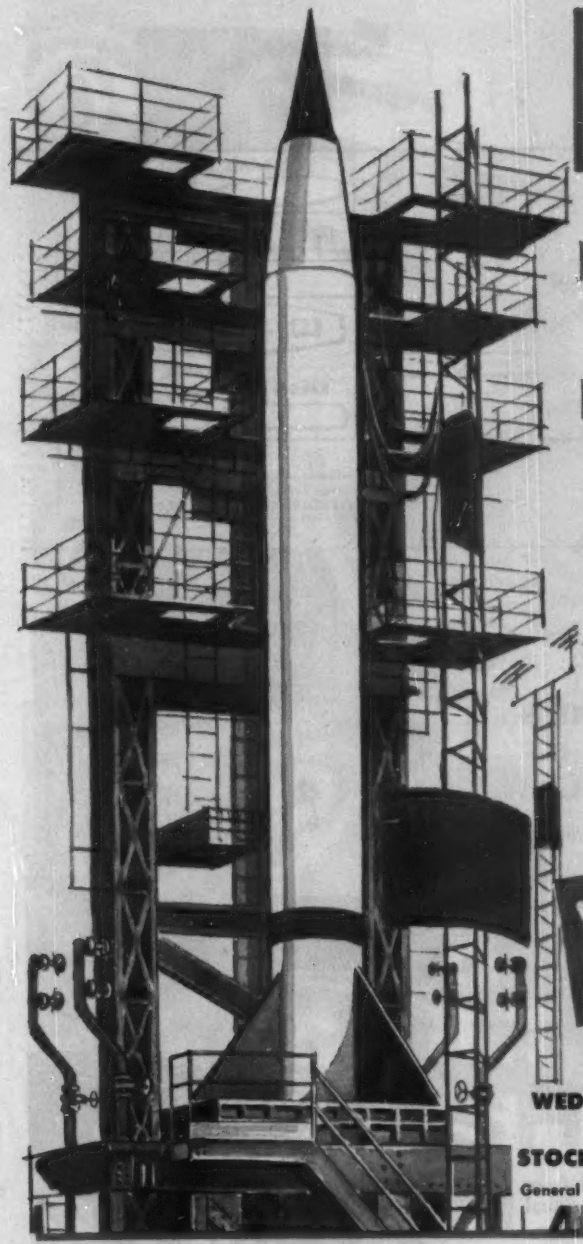
world's largest family of valves*



* and in this family there's a valve for every flow control requirement—for handling water, oil, gas, air, steam and corrosive fluids—available in the most required sizes and types. If your local distributor can't supply you, or if you need specially engineered valves for unusual conditions, write

THE WM. POWELL COMPANY • *Dependable Valves Since 1846* • **Cincinnati 22, Ohio**

THE VALVE WITH A FUTURE



▶ In the CHEMICAL INDUSTRY

▶ In the MISSILE INDUSTRY

The design of Wedgeplug Non-Lubricated Steel Plug Valves and their precision manufacture assure quick, easy, dependable operation; and, *absolute shut-off* at both low and high temperatures.

WRENCH OPERATED
HANDWHEEL OPERATED
WORM GEAR OPERATED
MOTOR OPERATED

WEDGEPLUG
NON-LUBRICATED
STEEL PLUG VALVES

For Complete Catalog Information Write to DEPT. M Box 2592

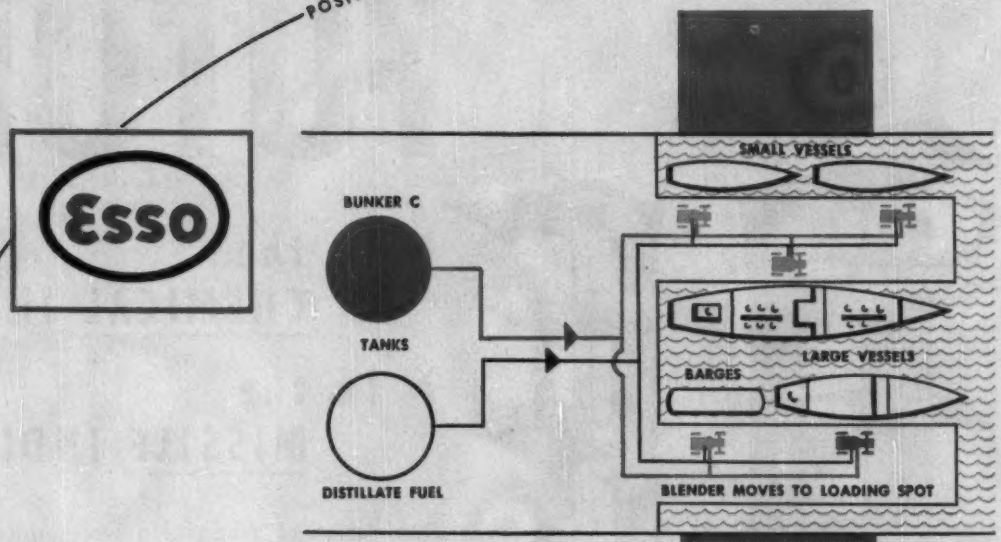
WEDGEPLUG VALVE COMPANY
Division of
STOCKHAM VALVES & FITTINGS
General Offices and Plant, Birmingham 2, Ala.

- Wedgeplug Valves are in use on Rocket Test Stands and Launching Pads.
- Carbon Steel and Alloy Steels.
- Service: Liquid and Gaseous Oxygen, at -300° F; Liquid and Gaseous Nitrogen; Jet Fuels.

SOLD THROUGH DISTRIBUTORS IN EVERY MAJOR CITY

For more data on advertised products, use Readers' Service Cards, last page.

POSITIVE CONTROL OF MATERIALS IN MOTION B-I-F



At Esso's Cristobal Bunkering Station . . .

SELF-POWERED MOBILE BLENDER PROVIDES ON-THE-SPOT BLENDING OF CUSTOMIZED BUNKER FUELS!

Terminal operators can now deliver any desired blend without advance notice . . . with a Proportioneers Mobile Blender. The simplicity and flexibility of this versatile blender have completely revised the economics of bunkering operations.

IT'S SELF-POWERED! No air, steam, or electric lines required. The blend valve is hydraulically actuated by the line fluid.

NO INSTALLATION COST! The Blender can be immediately moved to any loading spot . . . eliminates need for new tankage and costly manifolding.

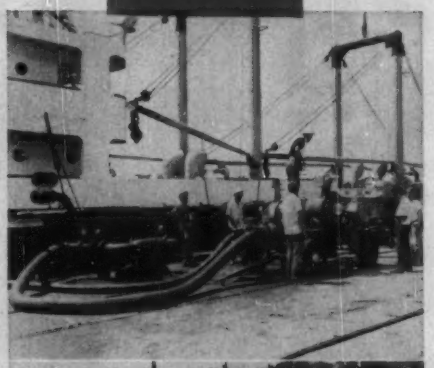
NO CONTAMINATION . . . tank-to-dock lines hold only Bunker C and distillate fuels. Custom blends are made at dockside.

NO SPECIAL PERSONNEL TRAINING REQUIRED . . . operation is this simple:

- move Mobile Blender into position
- hook up *two* component lines and *one* product line
- set ratio control to deliver any intermediate fuel from 90% residual fuel and 10% distillate — to 50% residual and 50% distillate

GREATER ACCURACY! The positive displacement meters accurately register the amount of oil delivered . . . on the spot . . . faster!

Make the move to greater profits . . . request complete data on this unique Blender. Write **Proportioneers, Inc., 412 Harris Avenue, Providence 1, R. I.**



PROPORTIONEERS
DIVISION OF
B-I-F INDUSTRIES
METERS FEEDERS CONTROLS

BUILT & SHIPPED... ON TIME

Today, modern oil refineries and chemical plants require more and more complicated pieces of fabricated equipment—too large to ship by rail or road. To meet this need, Sun Ship specializes in building and shipping large carbon or alloy steel units by water (inland, coastal or overseas)... directly from our plant.

SUN SHIP
BUILDING & DRY DOCK CO.
CHESTER, PENNSYLVANIA

For more data on advertised products, use Readers' Service Cards, last page.

9 bright new lights in the industrial world

Stone & Webster Engineering Corporation brings a world of experience to new projects and problems . . . all around our growing industrial globe.

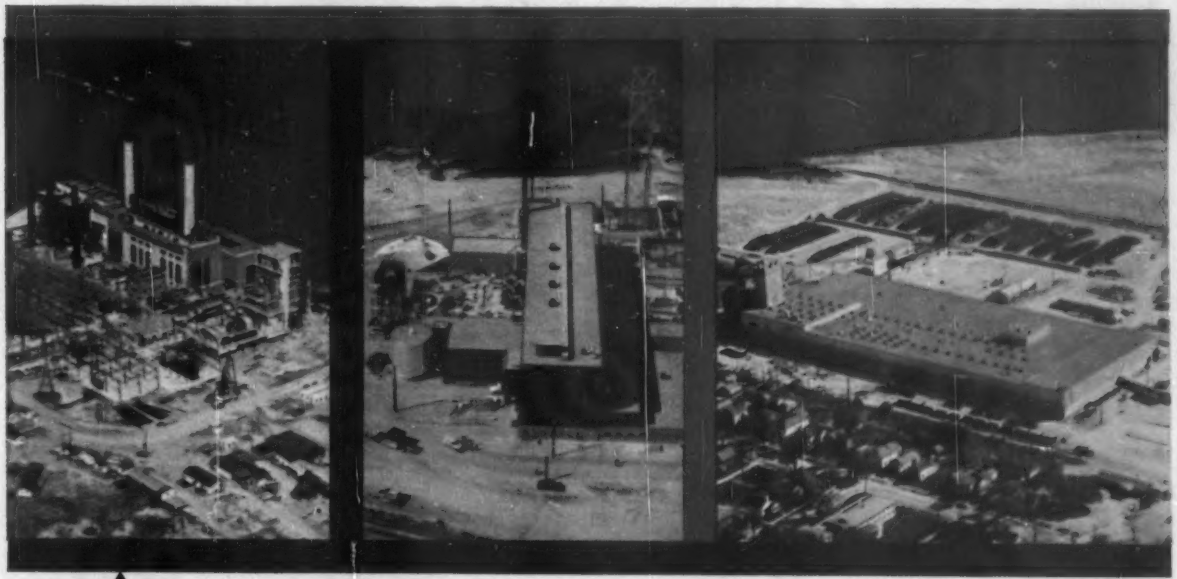
Steam and hydroelectric facilities, chemical plants, refineries, factories, breweries, hospitals, laboratories, pulp and paper mills . . . Stone & Webster takes pride in such continuing contributions to the world's industrial development.

Stone & Webster engineers can be found on many jobs . . . designing and constructing plants . . . developing special processes and equipment . . . helping business with appraisals, reports and consulting advice on a full range of financial and technical problems.

The successful application of Stone & Webster's varied engineering skills has reduced costs . . . construction and operating . . . for many clients in many fields . . . a big reason why 80% of our present work is for companies we have served before.

No matter what the magnitude or complexity of a project, Stone & Webster's integrated organization can produce the trained personnel to complete it . . . thoroughly, successfully, on schedule . . . anywhere in the world.

For further information write or call Stone & Webster Engineering Corporation at 90 Broad Street, New York City, or contact our nearest office.



STONE & WEBSTER

ENGINEERING CORPORATION

A SUBSIDIARY OF STONE & WEBSTER, INC.

New York Boston Chicago Pittsburgh Houston San Francisco Los Angeles Seattle Toronto

Stainless steel lining extends life of catalytic polymerization tower

Two months after going on stream, this catalytic polymerization tower shut down. Its carbon steel plates had corroded halfway through.

Phosphoric acid catalyst, temperatures up to 375°F, and pressures up to 500 pounds per square inch did the damage.

Refinery engineers then had a fabricator line the tower with Type 316 chromium-nickel stainless steel . . . and put in stainless caps and trays.

After 21 months of service, inspection showed the stainless lining still in excellent condition, with many more months of service yet to come.

For your corrosion problem . . . it may pay you to consider the properties of chromium-nickel stainless steel. It provides not only outstanding corrosion resistance, but also high strength, fabricability and ease of cleaning. Inco's Corrosion Engineering Section has a large amount of information on stainless steels . . . and many other alloys used in the petroleum industry. We'd be glad to share this data with you.

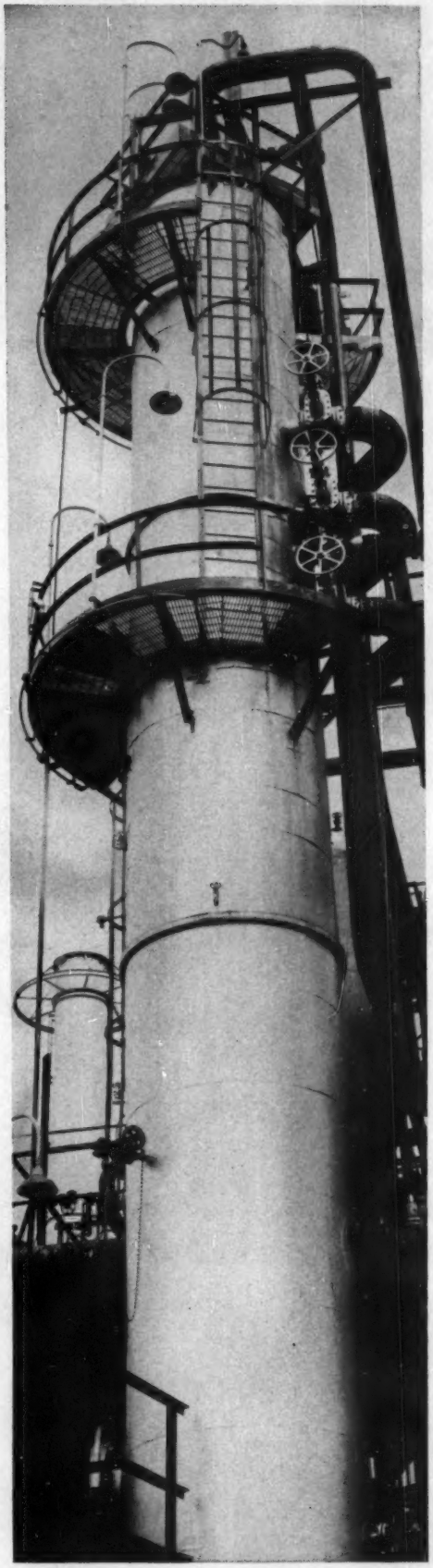
For immediate reference . . . the 34-page booklet, Corrosion Resisting Properties of the Austenitic Stainless Steels, discusses mechanism and factors of corrosion in various atmospheres. If you'd like to have a copy of this informative, useful handbook, just send a postcard to Inco.

The International Nickel Company, Inc.

67 Wall Street New York 5, N. Y.

INCO TRADE MARK

INCO NICKEL



for plastics and resins:

90 plants

20 products

1 builder

Blaw-Knox, pioneer in the industry, sets the pace in designing and building plants for polymer and resinous compound production.

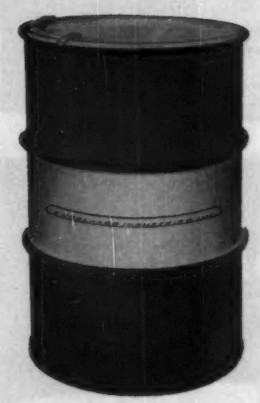
Blaw-Knox has led for twenty-five years in plant development for products ranging from condensation polymers such as alkyds and polyesters to addition polymers including synthetic rubber, polyvinyl chloride and polyvinyl acetate. Blaw-Knox construction parallels the mushrooming growth of the industry.

Blaw-Knox unexcelled know-how will pay off on your next project. A complete service is available—from preliminary planning to initial operation. For details contact Blaw-Knox Company, Chemical Plants Division with headquarters in Pittsburgh. Branch offices in New York, Chicago, Haddon Heights, N. J., Birmingham, Washington, D. C., San Francisco.

for plants of distinction...

BLAW-KNOX

For more data on advertised products, use Readers' Service Cards, last page.



higher octane levels and longer catalyst life...with existing equipment

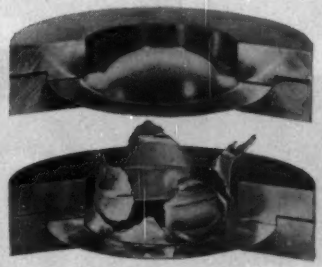
If you have the problem of increasing octane rating and production, investigate Sinclair-Baker RD 150! You can do it with your existing equipment, merely by replacing with Sinclair-Baker RD 150 Platinum Catalyst. Its efficiency in producing important yield increases at high octane levels is a matter of record. The long period of RD 150 operation is unmatched by any other catalyst . . . further, it is regenerative in situ! Costs are sharply reduced to lowest level. A representative will be glad to give you detailed information upon request. All data of confidential nature are of course treated accordingly. Literature is available.

CHEMICAL DIVISION • 113 ASTOR STREET
NEWARK, N.J.

for detection, measurement of oxygen or hydrogen impurities in other gases

This SUPER SENSITIVE DE-OXO INDICATOR continuously measures oxygen or hydrogen present as impurities in other gases. Accurately indicates from 0.0002% to 0.0200% (2 to 200 parts per million) oxygen and from 0.0004% to 0.0400% hydrogen. A dual range permits measurement of up to 0.25% oxygen or 0.5% hydrogen.

CHEMICAL DIVISION • 113 ASTOR STREET
NEWARK, N.J.



instant automatic release of excess pressure

Platinum, gold, and silver are now generally recognized as specifics when dealing with corrosion. Each is resistant to the corrosive effects of an important group of liquids and gases and will remain unattacked under conditions that would render many base metal materials useless. These rupture discs, depending on material selected, are guaranteed to be burst ± 5% of specified pressure.

BAKER PLATINUM DIVISION • 113 ASTOR STREET
NEWARK, N.J.

CHEMICAL DIVISION

ENGELHARD INDUSTRIES, INC.

EXECUTIVE OFFICES:
113 ASTOR STREET • NEWARK 2, NEW JERSEY

BAKER PLATINUM DIVISION

IN PRESSURE OR VACUUM DISTILLATION METAL PALL RINGS PROVIDE MAXIMUM SEPARATION—MAXIMUM CAPACITY

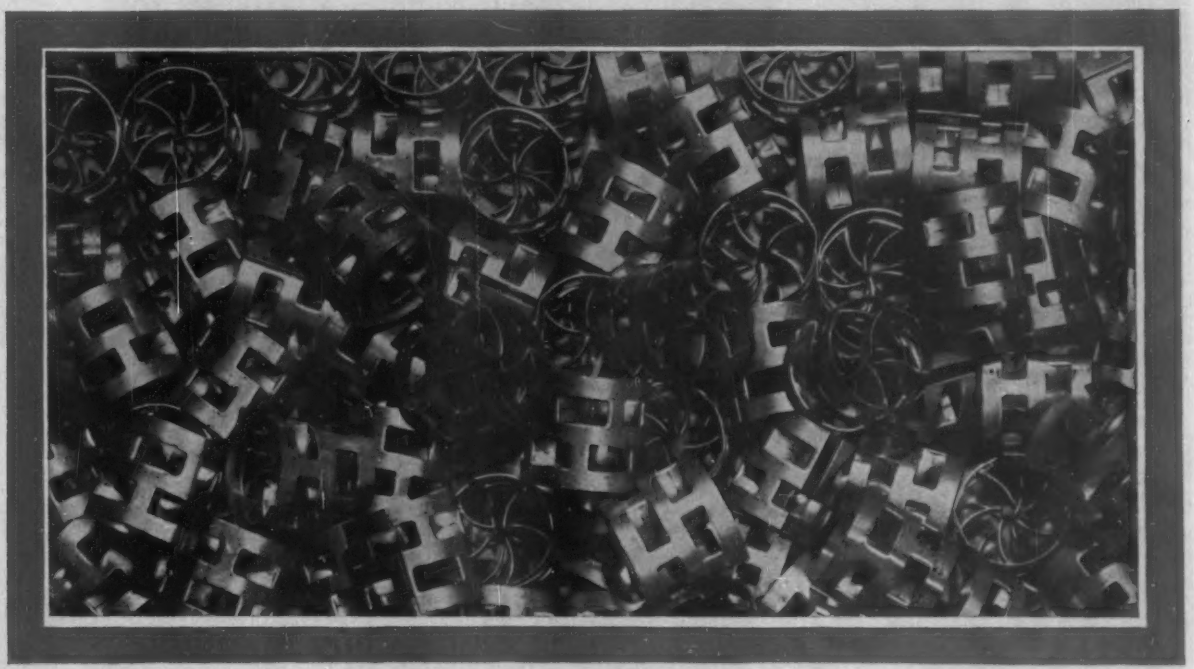
. . . with a minimum size shell

The superiority of metal Pall Rings is nowhere more clearly established than in distillation operations. Here two characteristic advantages of the Pall Ring come into play: (1) extremely low pressure drop, and (2) exceptional internal distribution at the low liquid rates employed in distillation.

In bubble cap towers or distillation columns packed with raschig rings the higher pressure drops necessitate higher pressures and higher boiler temperatures. Not infrequently the temperature required is so high as to invite product break down.

Not only can lower pressures and lower boiler temperatures be employed when the column is packed with metal Pall Rings but the fractionating efficiency of the column can be improved as much as 25% to 40%. In new construction the higher efficiency of the metal Pall Ring permits substantially smaller shells to be employed.

Metal Pall Rings are now being made in the ⅝", 1", 1½" and 2" sizes from carbon steel, the 18-8 series of stainless steels, monel, inconel, titanium, aluminum and copper.

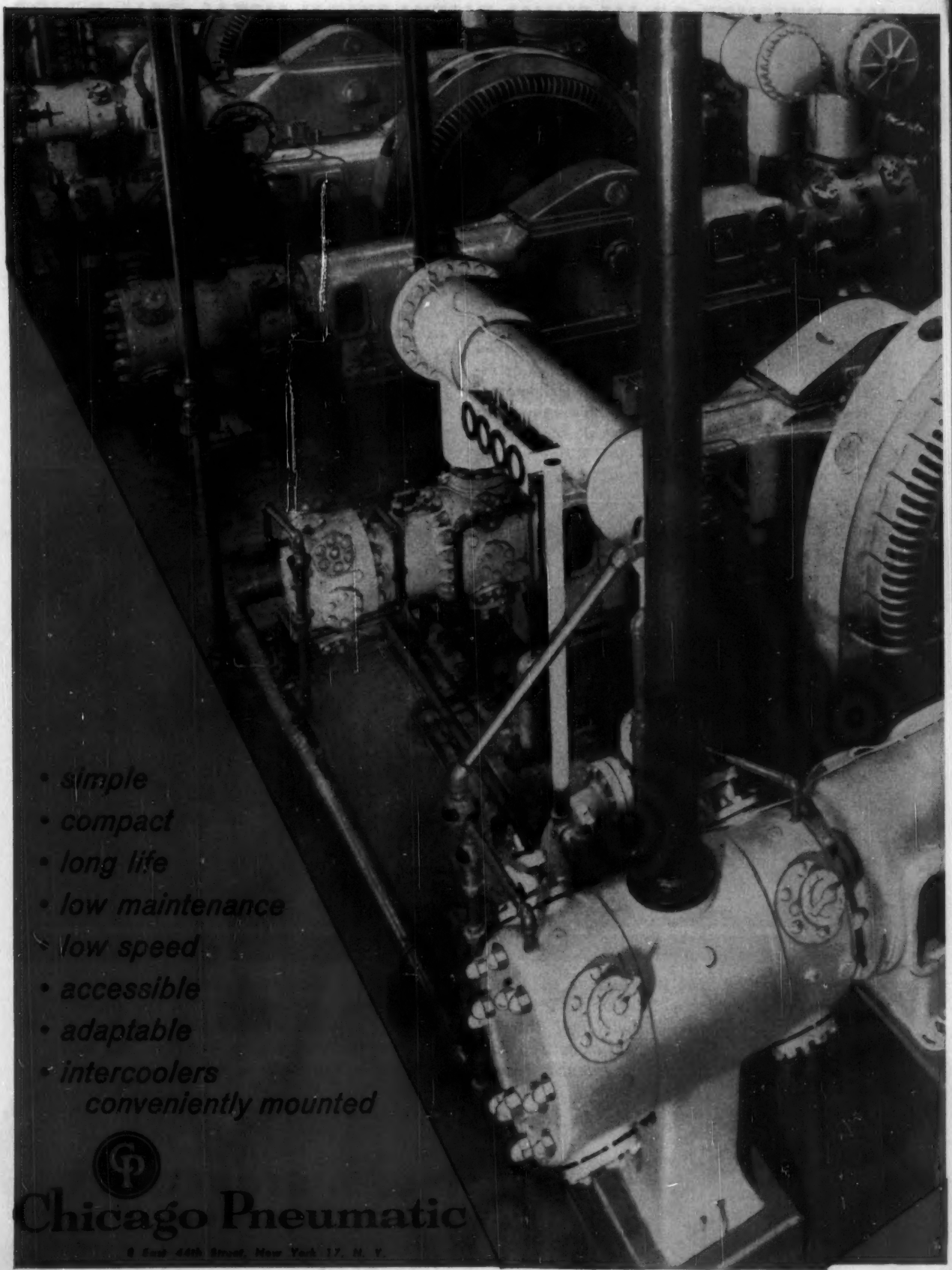


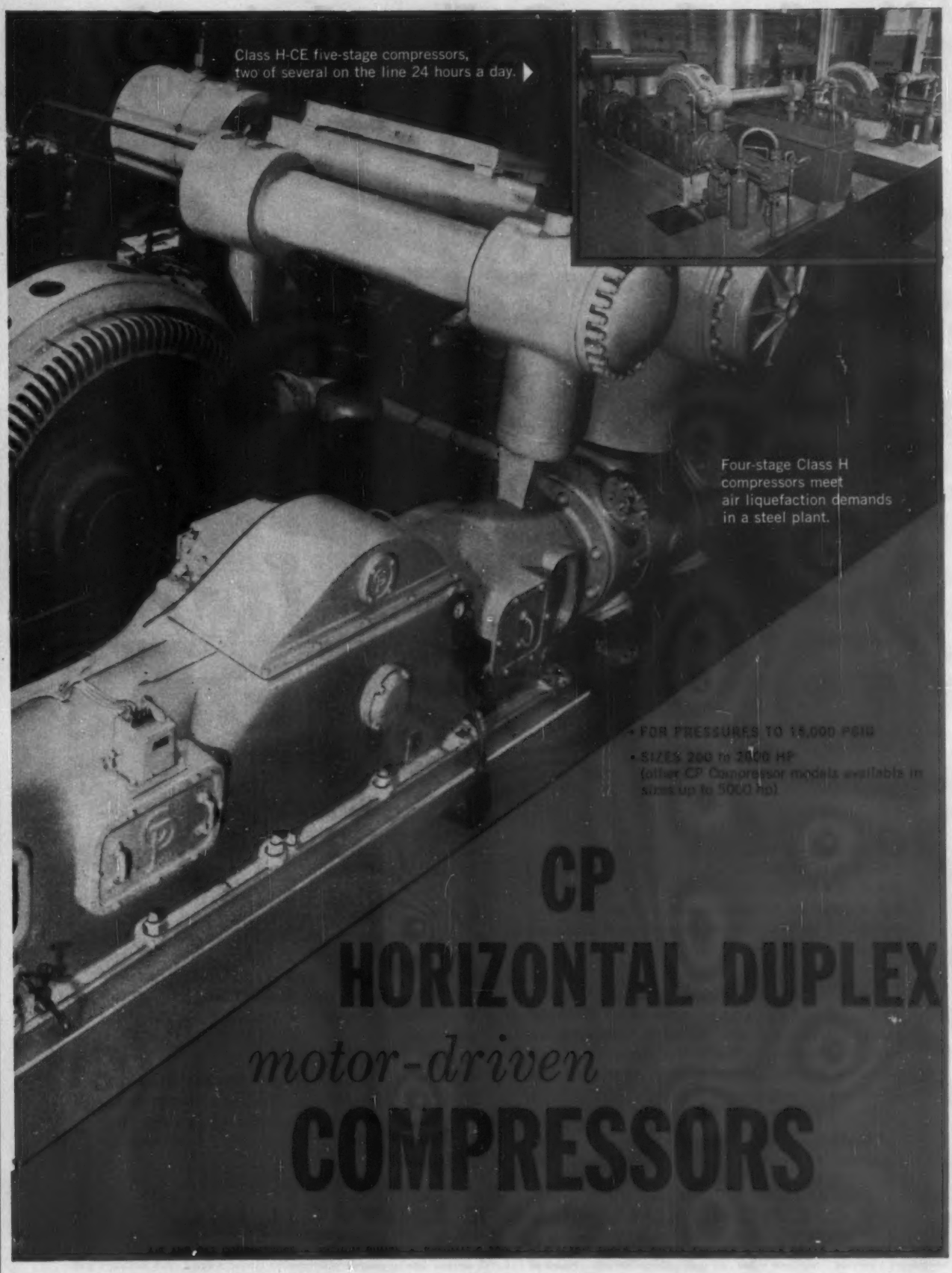
The metal Pall Ring is similar to the raschig ring in that height and diameter are equal. In the raschig ring the interior wall is mostly inactive providing little or no active contact between phases. In the metal Pall Ring, sections of the wall are stamped and bent inward, thus making the inner wall an active, working surface. Pressure drop is less than half that of raschig rings, resulting in a much greater capacity per unit of tower area.

Write today for engineering data on metal Pall Rings.

U. S. STONEWARE
AKRON 9, OHIO

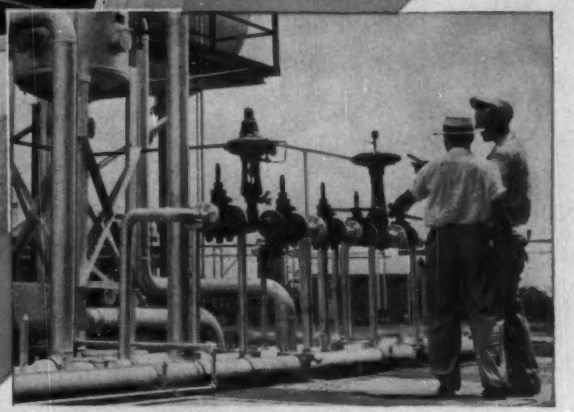
224-F


• simple
• compact
• long life
• low maintenance
• low speed
• accessible
• adaptable
• intercoolers
conveniently mounted
Chicago Pneumatic
6 East 44th Street, New York 17, N. Y.



For more data on advertised products, use Readers' Service Cards, last page.

You Can Count On These Engineering And Field Services When You Buy BS&B CONTROLS!



5 "Plus" Factors Are Your Guarantee Of Satisfaction With BS&B!

1 Sales Engineering: BS&B Sales Engineers and Representatives are strategically located throughout the United States, Canada and Latin America to assist you with specifications, operation and maintenance problems involving BS&B Controls.

2 Application Engineering: BS&B Controls Application Engineers are specialists in instrumentation and process control applications, can analyze your control systems from the standpoint of over-all plant design, operation and maintenance requirements.

3 Start-Up and Field Service: A BS&B Engineer will assist you in equipment calibration and control point settings on BS&B Controls during your start-up period, and will service any BS&B equipment after your plant is put "on-stream".

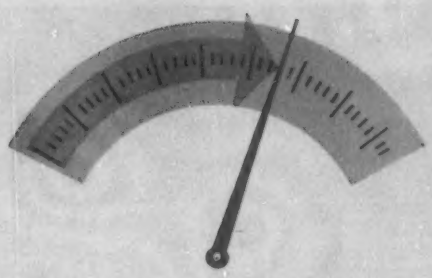
4 Research, Development and Testing: BS&B has one of the industry's most complete and up-to-date laboratories where control equipment is constantly undergoing development and actual test data are utilized to offer a *specific* solution to your *specific* controls problem.

5 Branch and Central Stocks: Standard BS&B Controls items and replacement parts are stocked at strategic locations to meet your field replacement and emergency maintenance problems.

BLACK, SIVALLS & BRYSON, INC.

Controls Division, Dept. 4-F6 7500 East 12th Street Kansas City 26, Missouri

For more data on advertised products, use Readers' Service Cards, last page.



TO STEP UP EFFICIENCY OF SULFONATIONS, SULFATIONS

...USE SULFAN®

(stabilized sulfuric anhydride)

Step up sulfonation efficiency. "Sulfan" has 99.5% SO_3 available for sulfonation reactions. For many applications, "Sulfan" offers nine times as much usable SO_3 as 100% sulfuric acid . . . over three times as much as 20% oleum. This can mean a considerable saving in operating costs.

Step up processing efficiency. With "Sulfan," there is no waste acid. This means that you can increase batch sizes or get more rapid through-put . . . often double without increasing size of equipment! Since no water is formed when "Sulfan" is used for sulfonation, the waste acid problem inherent with use of sulfuric acid or oleum is eliminated.

These benefits alone make "Sulfan" worth your thorough investigation. You may be able to realize other important process economies and advantages too.

"Sulfan" is readily available in tank cars and 750-lb. drums.

Write today for confidential technical information on the use of "Sulfan" in *your* process.

Use "Sulfan" for:

Synthetic Detergents
Dye Intermediates
Petroleum Fractions
Textile Specialties
Pharmaceuticals
Fatty Acids
Lubricant Additives
Agricultural and Industrial Emulsifiers

Product Development Department

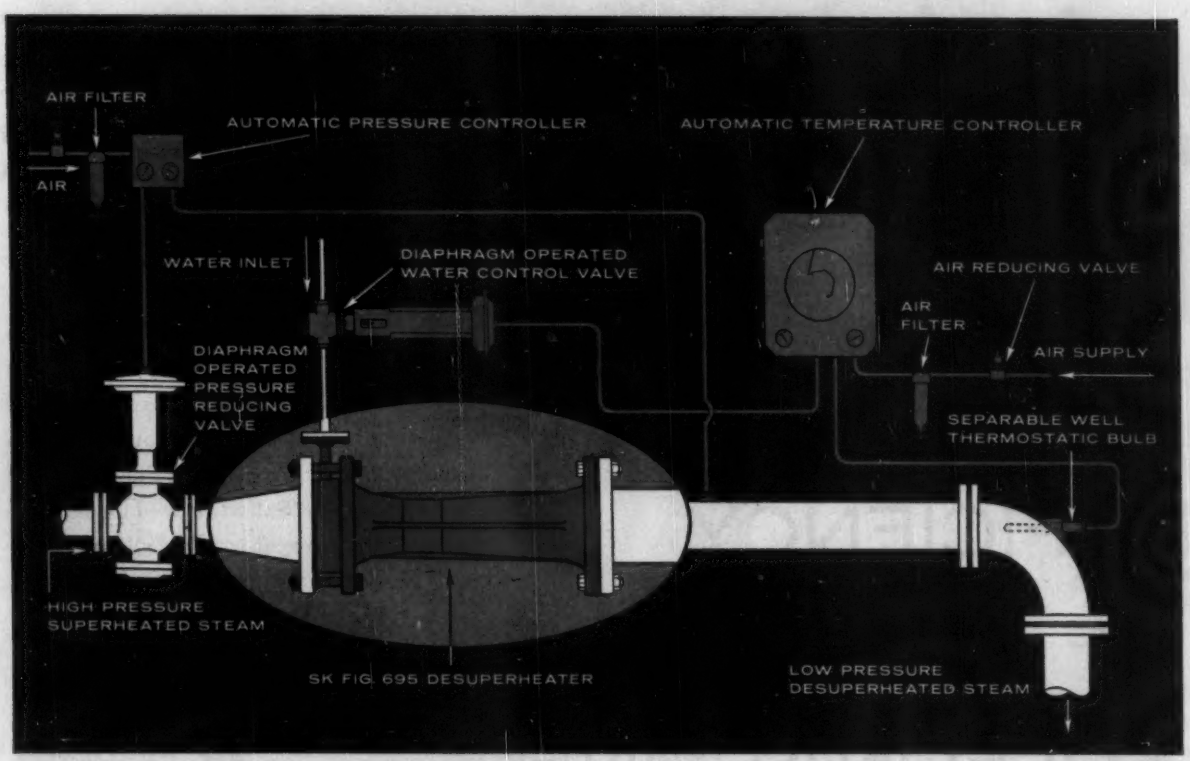
GENERAL CHEMICAL DIVISION

40 Rector Street, New York 6, New York

Allied Chemical

Basic Chemicals for American Industry

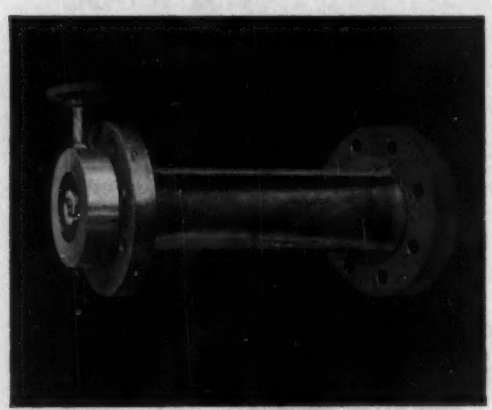
Offices: Albany • Atlanta • Baltimore • Birmingham • Boston • Bridgeport • Buffalo • Charlotte • Chicago • Cleveland (Miss.) • Cleveland (Ohio) • Denver Detroit • Houston • Jacksonville • Kalamazoo • Los Angeles • Milwaukee • Minneapolis • New York • Philadelphia • Pittsburgh • Portland (Ore.) • Providence San Francisco • St. Louis • Seattle • Kennewick, Vancouver and Yakima (Wash.) **In Canada: The Nichols Chemical Co., Ltd. • Montreal • Toronto • Vancouver**



Reduce Steam Temperature for Process Operations

with this light, easily-controlled Desuperheater

SK Fig. 695 Venturi Type Desuperheater. An important feature of this desuperheater is the fact that the water need not be at higher pressure than the steam entering the desuperheater. As noted in description, right, water can enter the unit at inlet steam pressure.



The SK Venturi Type Desuperheater, shown in the illustrations above and at left, is designed to reduce the temperature of superheated steam to the lower temperatures required for use in process operations and for operating plant auxiliaries.

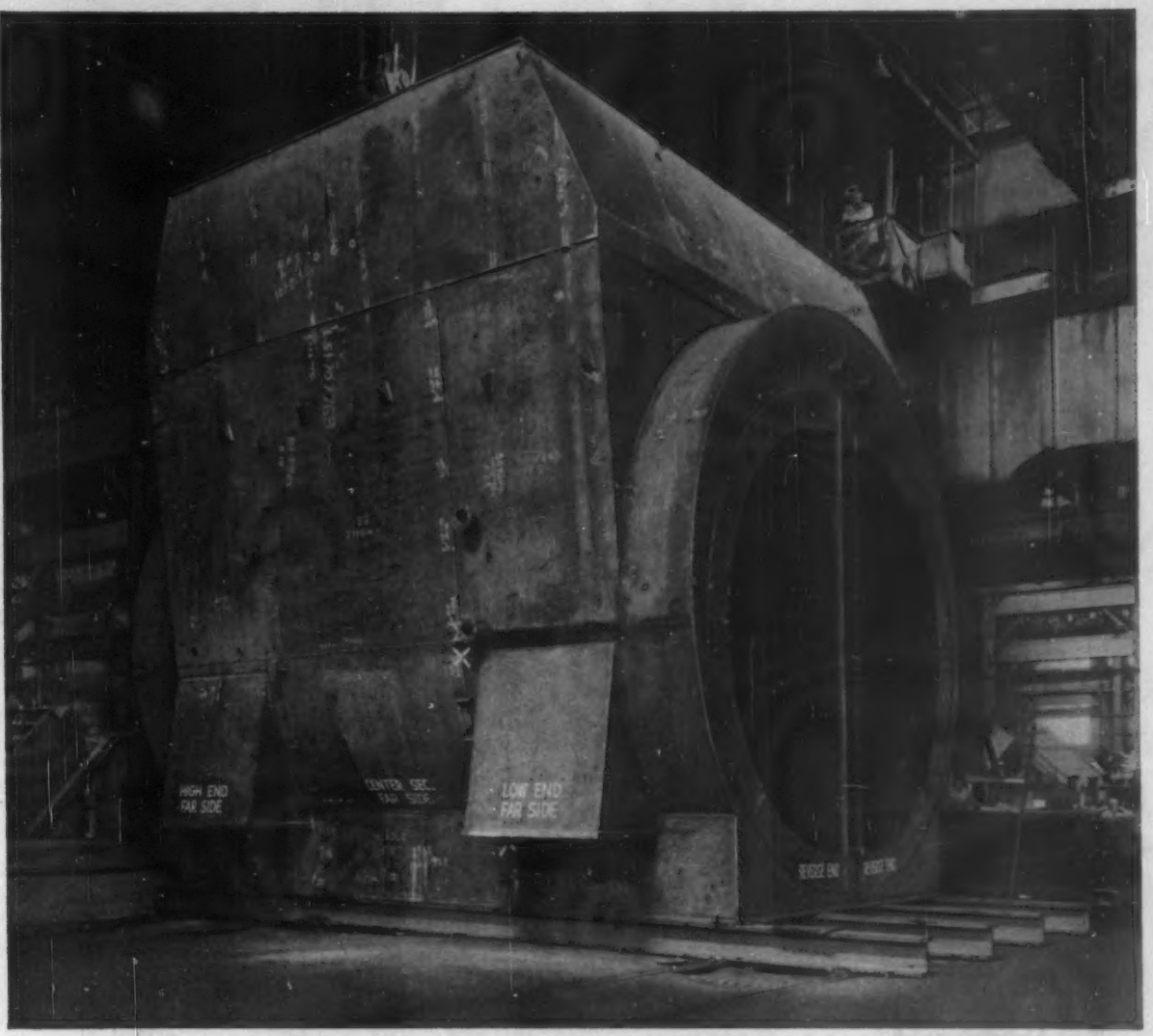
These Desuperheaters are light in weight and small in dimensions—are supported directly by the superheated steam line. In addition, they are simple in construction, provide straight-through flow with only a small pressure drop. Because these units are designed for application with automatic control, they are particularly well suited for process and petroleum plants where steam flow varies. They can, however, be used without controls where steam flow is steady. In such cases only a separator need be added.

The Venturi Type Desuperheater reduces steam temperature by bringing water into contact with the superheated steam. The water pressure is low since it need only equal the operating steam pressure. The water is preheated in the chamber around the water diffuser and issues, through many small jets, into the steam stream. Since the steam-water mixture is discharged through the desuperheater outlet in a fog-like condition, without contacting the sidewalls, maximum desuperheating effectiveness is obtained and minimum wear occurs in the discharge piping.

The particular desuperheater shown is one of four types made by SK for process plants. Complete details on all types are contained in Bulletin 6D. Write for a copy.

JET APPARATUS: Ask for Condensed Bulletin J-1.
ROTAMETERS & FLOW INDICATORS: Ask for Condensed Bulletin M-1.
VALVES: Ask for Condensed Bulletin V-1.
HEAT TRANSFER APPARATUS: Ask for Condensed Bulletin HT-1.
GEAR PUMPS: Ask for Bulletin 17-A.

Schutte and Koerting
COMPANY
MANUFACTURING ENGINEERS SINCE 1876
2257 State Road, Cornwells Heights, Bucks County, Pa.



Operator of overhead crane (top, right) and workmen on shop floor are dwarfed by the enormousness of this surface condenser casing fabricated by B-L-H's Eddystone Division.

No welding job too big for vast B-L-H facilities

No welding job—not even the biggest pressure vessels—is too large for the facilities of Baldwin-Lima-Hamilton's Eddystone Division. The fabricating shop covers 15 acres and is divided into 13 bays, each 80 ft. wide and 600 ft. long.

Sheer size does not, of course, even begin to tell the whole story. From automatic tracer flame cutters to individual hand welders, we have a tool for every conceivable operation. And there is no reason for you to spend money transporting formed parts to Eddystone for welding—or completed weldments to some other shop for machining. We can handle every phase of the job—from design right through to delivery. No wonder so many companies bring the big ones to B-L-H.

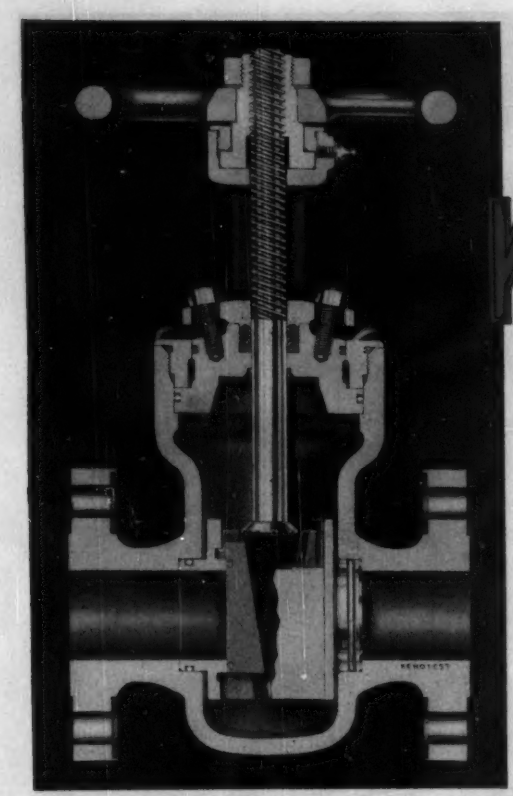
Our illustrated Weldment Bulletin 7001 will give you an excellent idea of our vast facilities. You should have it in your files. For a copy, write to B-L-H Corporation, Philadelphia 42, Pa.

BALDWIN · LIMA · HAMILTON

Eddystone Division

Philadelphia 42, Pa.

Hydraulic turbines • Weldments • Dump cars • Nonferrous castings • Special machinery • Bending rolls • Machine tools



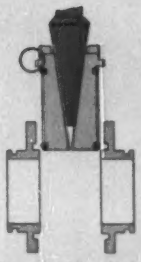
Eliminate those costly leaks...
...with the new

KEROSEAL® VALVE

- **bubble-tight**
- **non-lubricated**
- **optional flow**
- **full opening**
- **double block and bleed**

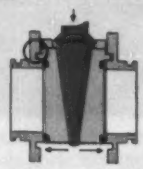
Handles a wide range of liquids and gases in the Petroleum and Petrochemical Industries.

A bubble-tight seal—among other exceptional features—makes the revolutionary KEROSEAL valve an important asset to the gas, petroleum and chemical industries. This seal, effected mechanically and without the use of lubricants, eliminates wear, frictional drag, wiping and consequent galling of seating surfaces. All standard types of operators may be employed, whether handwheel, gear or motor. Write for the KEROSEAL valve bulletin for more information on this versatile new valve.



Valve fully open. In closing, discs and spreader move down, perpendicular to flow.

Discs are positioned without drag across seat. When disc lug rests on seat ring, continued downward motion of spreader moves discs parallel to flow.



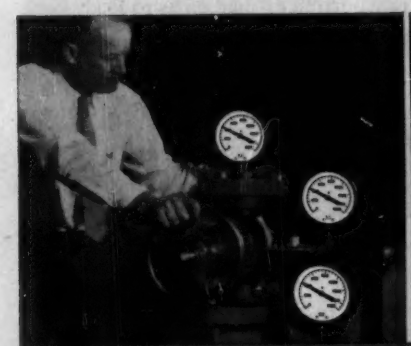
Valve fully closed. Spreader holds discs bubble-tight against seat rings. When opening, seated discs are retracted with the same parallel motion—again with no drag against seating surfaces. The upward motion does not begin until discs are clear of seat ring.

KEROTEST

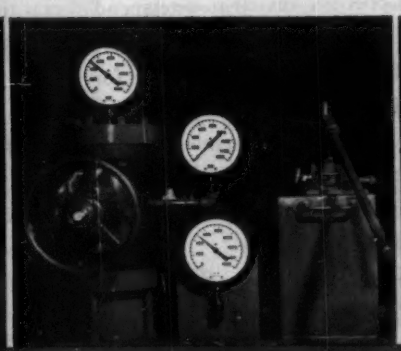
KEROTEST MANUFACTURING COMPANY
2514 Liberty Avenue, Pittsburgh 22, Pa.

In Canada, Kerotest products are manufactured and distributed exclusively by Guelph Engineering Company, Guelph, Ontario.

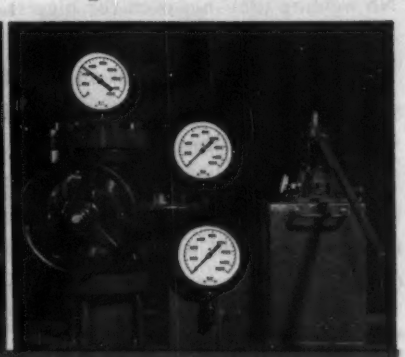
Demonstrating effectiveness of upstream and downstream seating on KEROSEAL Valves—with end flanges blanked and valve fully opened—pressure built up (hydraulic oil)—Figures 1-2-3 follow.



The valve was closed, resulting in three separate pressure chambers; i.e., body cavity between seats and two port cavities.

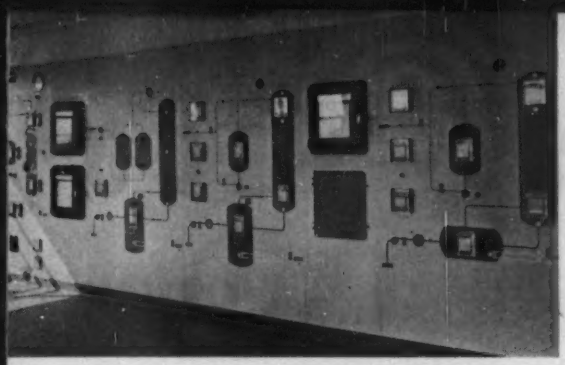


Pressure released in body cavity (center gauge now reads zero). Pressure remained constant in each port cavity.



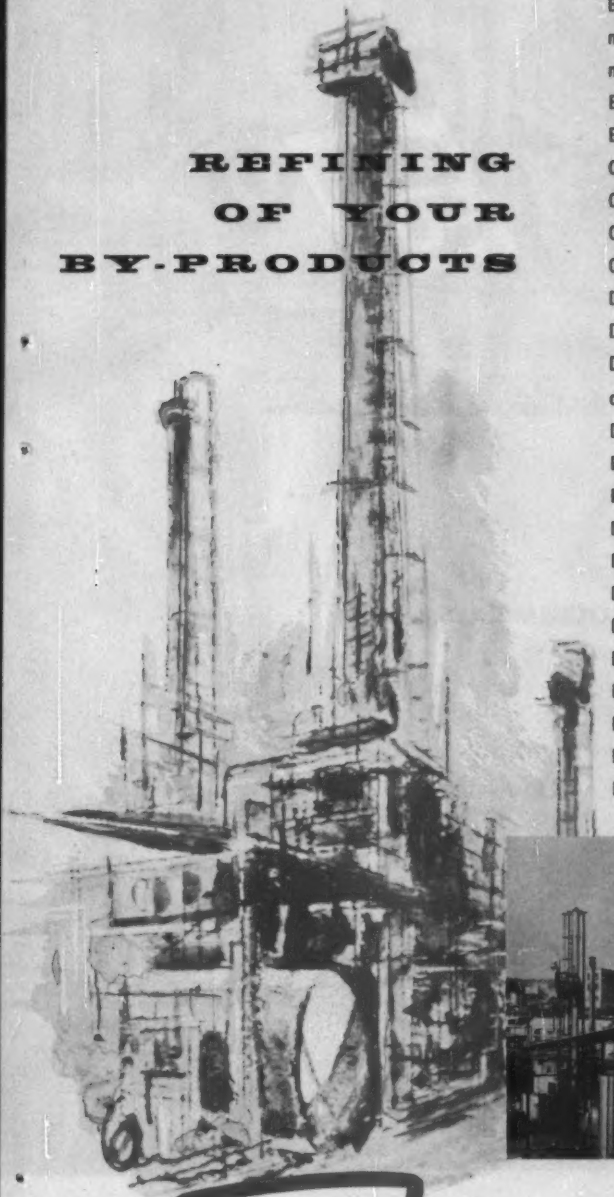
Pressure released from bottom port cavity of valve. Top port cavity remains at constant pressure.

For more data on advertised products, use Readers' Service Cards, last page.



The facilities and experience of Truland may be employed advantageously for the economical upgrading and disposal of solvent mixtures and organic by-products.
Our technically trained personnel are available to discuss the refining of any solvent mixture or organic by-product.

REFINING OF YOUR BY-PRODUCTS



Partial List
of materials processed

- Acetone
- Amyl Acetate
- Amyl Alcohol
- Benzene
- n-Butyl Acetate
- n-Butyl Alcohol
- Butyl Cresols
- Butylene Glycol
- Capryl Alcohol
- Carbon Tetrachloride
- Chlorbenzene
- Chloroform
- Dibutyl Phenol
- Dibutyl Phthalate
- Dicapryl Phthalate
- o-Dichlorbenzene
- Diethanolamine
- Diethylene Glycol
- Dimethyl Phthalate
- Dimethyl Sebacate
- Dipropylene Glycol
- Dodecyl Alcohol
- Dodecylbenzene
- Ethyl Acetate
- Ethylene Dichloride
- Ethylene Glycol
- Ethyl Hexanediol
- Ethyl Lactate
- Glycerine
- Glycol Ethers
- Hexyl Alcohol
- Isobutyl Alcohol
- Isodecyl Alcohol
- Isooctyl Alcohol
- Isophorone
- Isopropyl Acetate
- Isopropyl Alcohol
- Methyl Alcohol
- Methyl Amyl Alcohol
- Methylene Chloride
- Methyl Ethyl Ketone
- Methyl Hexyl Ketone
- Methyl Isobutyl Ketone
- Monoethanolamine
- Naphthas
- Nitrotoluols
- Nonyl Phenol
- Octyl Acetate
- Perchlorethylene
- n-Propyl Alcohol
- Propylene Glycol
- Pyridine
- Toluene
- Trichlorbenzene
- Trichlorethylene
- Tricresyl Phosphate
- Triethyl Amine
- Triethylene Glycol
- Trimethyl Borate
- Vinyl Acetate
- Xylene

Send *for new booklet which describes our operation*

TRULAND

TRULAND CHEMICAL COMPANY

EAST RUTHERFORD, NEW JERSEY

DIVISION OF THE TRUBEK LABORATORIES

300

25th ANNUAL EDITION

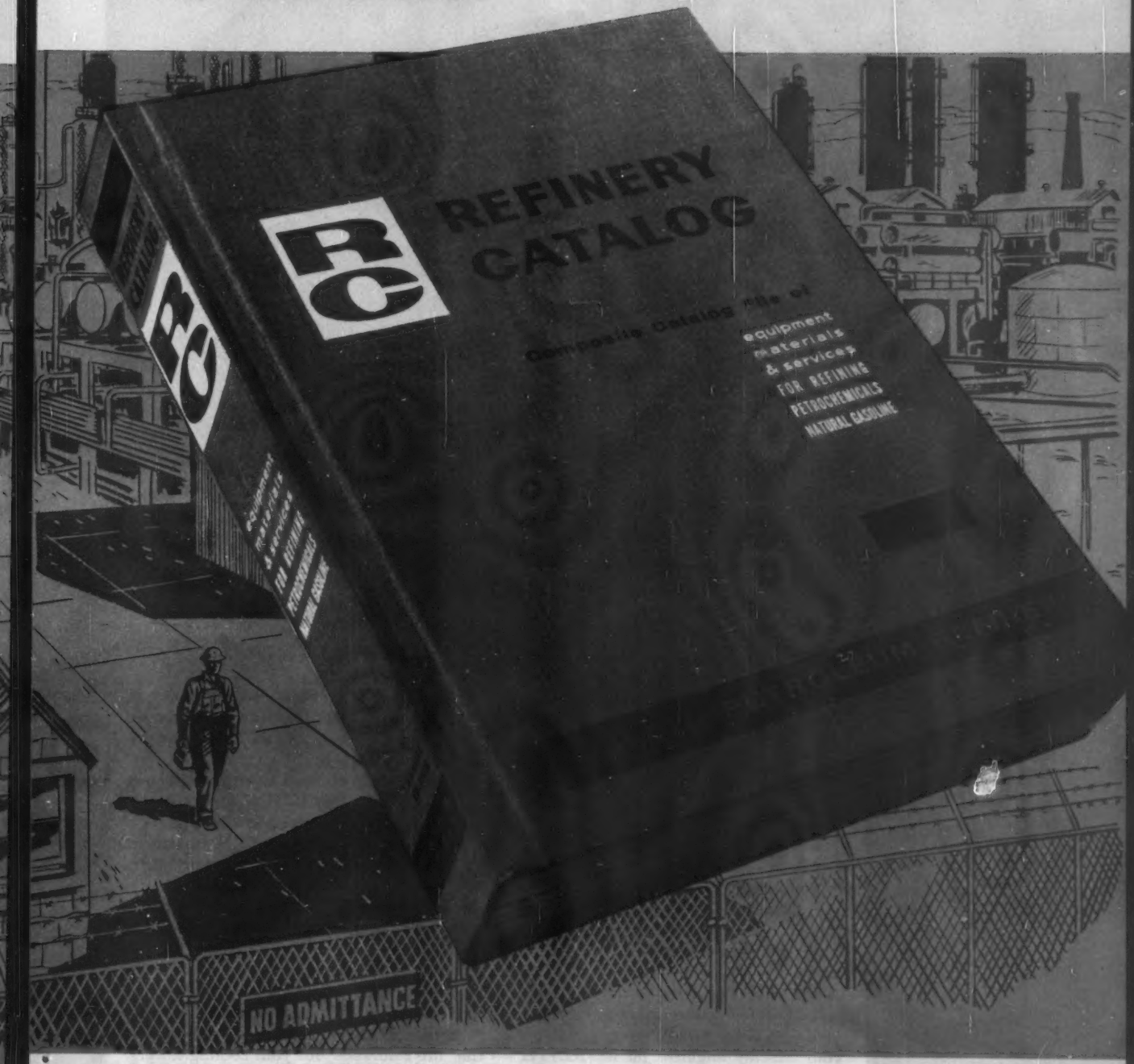
EQUIPMENT • MATERIALS • SERVICES
for REFINING • NATURAL GASOLINE • PETROCHEMICALS

In a hurry? Eight out of nine planners, buyers and specifiers turn to REFINERY CATALOG in preference to individual suppliers' literature when figuring a job. They know that REFINERY CATALOG is always current, that it's indexed and cross-indexed for quick, accurate reference. That's why more than 300 manufacturers and service companies put their complete or condensed catalogs in REFINERY CATALOG. Here they are "on call" 24 hours a day.

The next time *you* have a procurement problem, reach for a quarter-century of cataloging experience—look *first* in the one volume, easy-to-use REFINERY CATALOG.

SUPPLIERS ON CALL

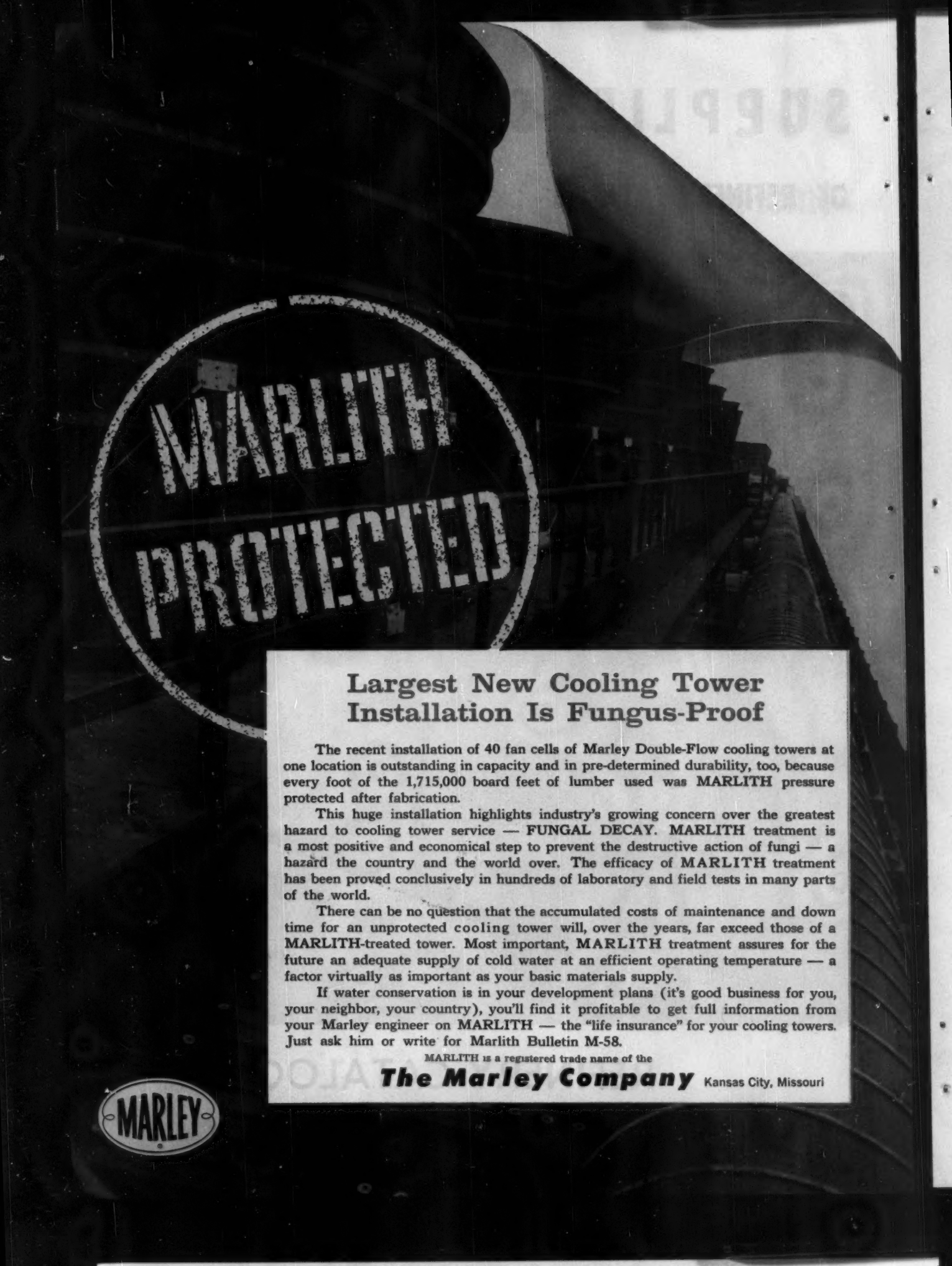
OF REFINERY CATALOG



REFINERY CATALOG

Published by Petroleum Refiner

For more data on advertised products, use Readers' Service Cards, last page.



Largest New Cooling Tower Installation Is Fungus-Proof

The recent installation of 40 fan cells of Marley Double-Flow cooling towers at one location is outstanding in capacity and in pre-determined durability, too, because every foot of the 1,715,000 board feet of lumber used was MARLITH pressure protected after fabrication.

This huge installation highlights industry's growing concern over the greatest hazard to cooling tower service — FUNGAL DECAY. MARLITH treatment is a most positive and economical step to prevent the destructive action of fungi — a hazard the country and the world over. The efficacy of MARLITH treatment has been proved conclusively in hundreds of laboratory and field tests in many parts of the world.

There can be no question that the accumulated costs of maintenance and down time for an unprotected cooling tower will, over the years, far exceed those of a MARLITH-treated tower. Most important, MARLITH treatment assures for the future an adequate supply of cold water at an efficient operating temperature — a factor virtually as important as your basic materials supply.

If water conservation is in your development plans (it's good business for you, your neighbor, your country), you'll find it profitable to get full information from your Marley engineer on MARLITH — the "life insurance" for your cooling towers. Just ask him or write for Marlith Bulletin M-58.

MARLITH is a registered trade name of the

The Marley Company Kansas City, Missouri

MARLEY

We're "Open" 24 Hours a Day in

REFINERY CATALOG

complete, quick reference information on

Lightnin® Mixers

The pages of REFINERY CATALOG are never closed . . . bringing you around the clock information on products and services. Because we know you prefer such a single-source reference, we have selected this Catalog to carry our catalog data to more than 8,500 buyers and specifiers in the refining, petrochemical and natural gasoline industry throughout the world. We believe this pre-filed data will be of time-saving value and convenience to you.

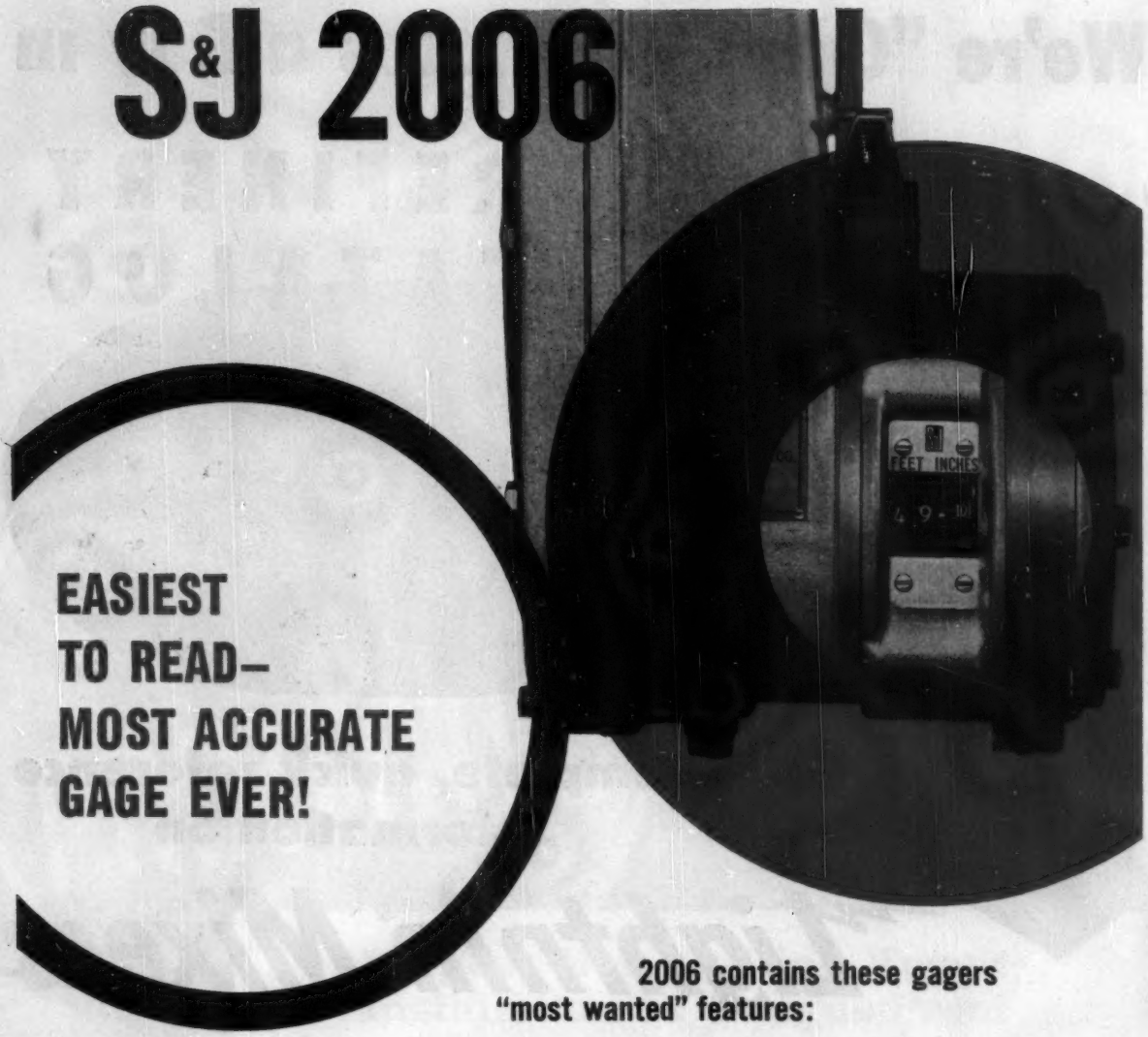
When you want quick facts on fluid mixing, turn to the catalog data in Refinery Catalog. There you'll find condensed catalog information on LIGHTNIN Mixers for any type of service. The LIGHTNIN catalog unit is made up of 16 fact-filled pages on mixer construction, impeller selection, scale-up, and mixer efficiency. If you can't find all the information you need, check the list of LIGHTNIN sales representatives and call the nearest one.

MIXING EQUIPMENT Co., Inc. 135 Mt. Read Blvd., Rochester 11, N.Y.

IN CANADA: Greey Mixing Equipment Ltd., 100 Miranda Ave., Toronto 10, Ontario

For more data on advertised products, use Readers' Service Cards, last page.

S&J 2006



EASIEST TO READ— MOST ACCURATE GAGE EVER!

2006 contains these gagers "most wanted" features:

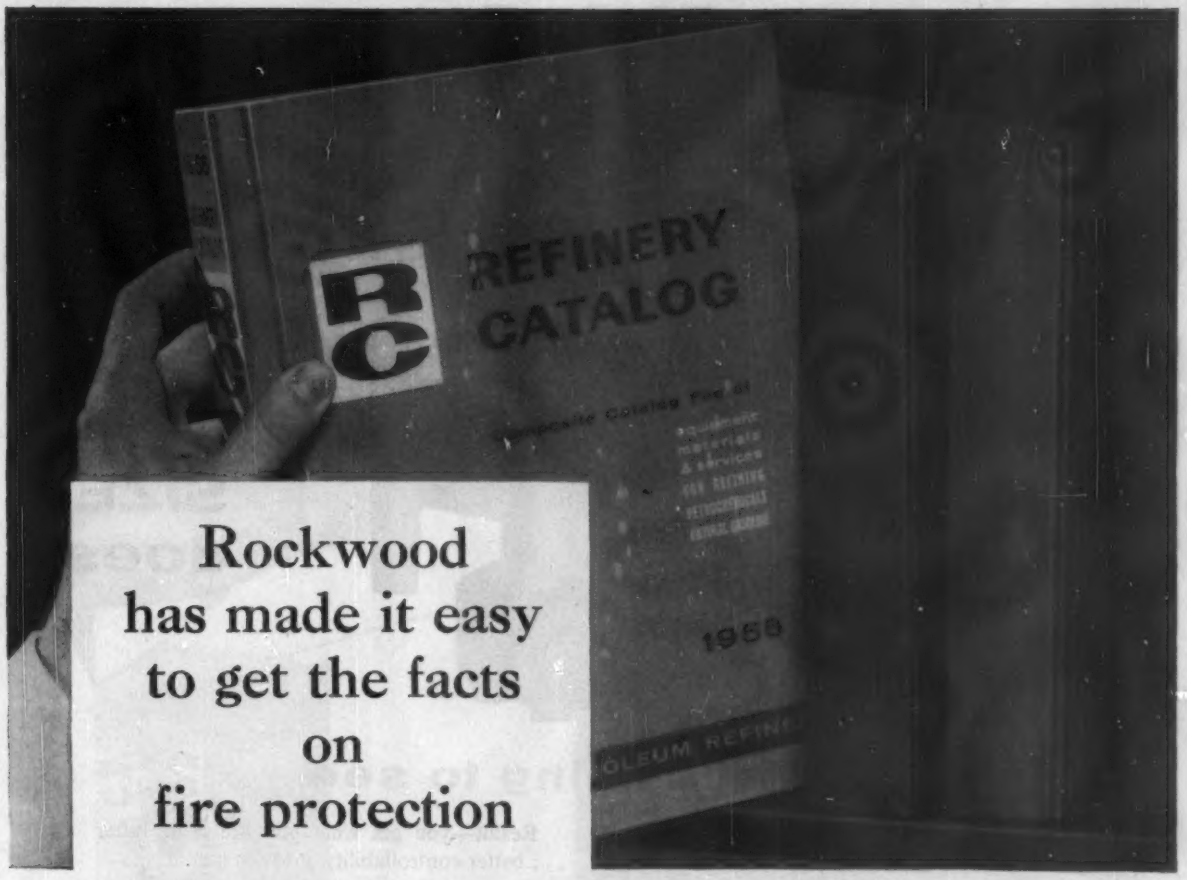
Large, white numbers on black for maximum visibility and accurate readings. Teflon bearings for minimum friction, greater gaging accuracy. Superior quality components, precision machining, clean, modern design for dependability and service. Rugged construction, minimum maintenance. Simple, fast adjustment. Easy attachment of transmitters for remote reading systems. These are some of the exclusive S&J features that make 2006 a major achievement in tank gages. Write for details today.

SHAND AND JURS | GENERAL PRECISION EQUIPMENT CORPORATION GPE

SHAND AND JURS COMPANY 2600 Eighth Street, Berkeley 10, California

Subsidiary of General Precision Equipment Corporation

4825



Rockwood has made it easy to get the facts on fire protection

It's a simple 1, 2, 3 step to get all the facts on fire protection in the Refinery Catalog.

Here's all you do...

1. ***Check the index,*** you'll find Rockwood Fire Protection Equipment conveniently listed.

2. ***Read the section,*** you'll get the facts on 15 types of Rockwood Fire Protection equipment, including the engineering data of each.

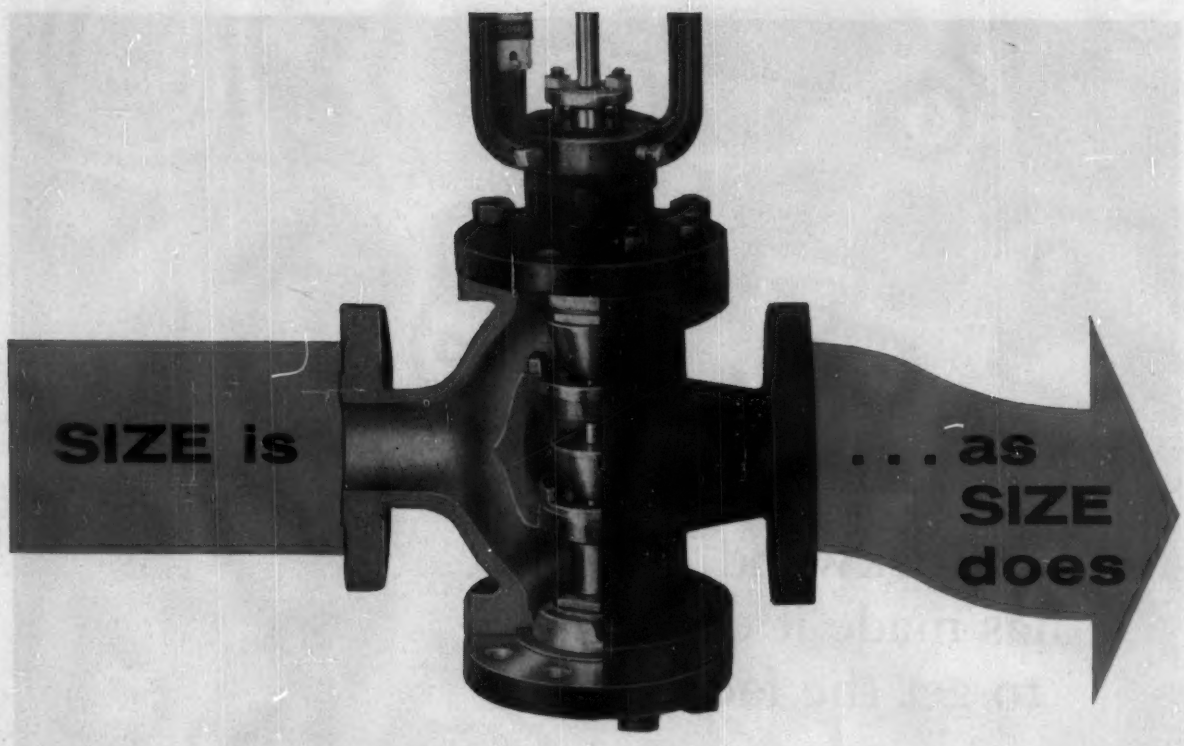
3. ***Write or phone for more facts*** and Rockwood will quickly send you the information you desire.

ROCKWOOD SPRINKLER COMPANY

Worcester 5, Mass.

Engineers Water... to Cut Fire Losses

For more data on advertised products, use Readers' Service Cards, last page.



C_v is the thing to see

Take a hard look at fundamentals when you buy diaphragm control valves.

Valves of the same size won't necessarily deliver the same *amount* of valve performance. Flow capacity, not nominal size, is the dollar dimension to look at.

K&M valves provide the largest flow coefficient available. That means, in some cases, you can use the next smaller size at a worthwhile saving in dollars. In all cases, K&M's higher C_v produces a smaller pressure loss in the body; it places the flow restriction where it belongs . . . at the controlled inner valve.

Averaging 140% of cross-sectional pipe area K&M valves provide more space for fluids to flow . . . smoothly, freely with less turbulence.

Result—you get what you are really after . . . better controllability at lower cost.

Why not size up your control valve buying decisions on a real—not nominal—size basis?

Request Bulletin CV53

C_v COMPARISON TABLE

Valve Size	K&M	Valve B	Valve C
¾"	10.9	8.4	8
1"	17.3	14.9	12
1½"	39.1	33.2	28
2"	61	57	48
2½"	97.7	71.0	72
3"	150	116	100
4"	219	197	165
6"	500	364	360

Based on the maximum Cv at rated travel through the valve body. From manufacturers' most recent slide rules or tables.

K&M

diaphragm control valves

Our 79th Year

KIELEY & MUELLER, INCORPORATED

Oldest Pressure and Level Control Valve Manufacturer

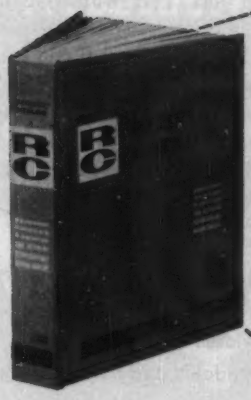
64 Genung Street, Middletown, New York

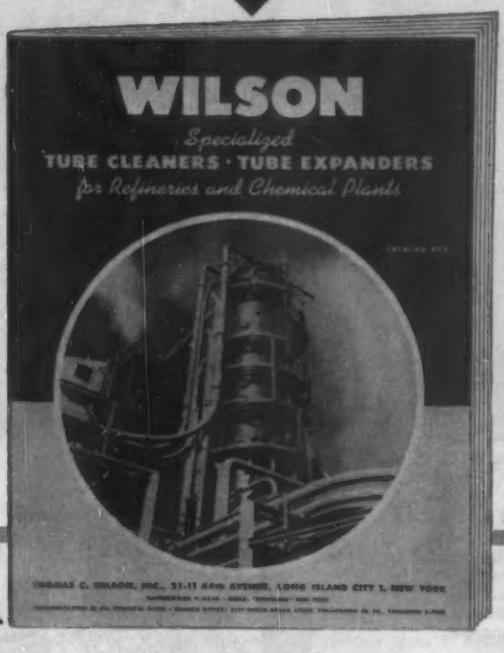
P.A. 1719-A

For more data on advertised products, use Readers' Service Cards, last page.

Look for it here

12 pages of helpful selection data





Here's what you will find in this Wilson Catalog

- **Air Motors** *for straight tubes*
- **Cutter Heads**
- **Pipe Cleaners**
- **Sleeves**
- **Hose and Couplings**
- **Air Valves**
- **Tube Cleaners** *for fouled heat exchanger tubes*
- **Air or Water Driven Motors** *for removal of spent catalyst*
- **Refinery Tube Expanders** *for refinery type fittings*
- **Tube Expanders** *for condenser and heat exchanger tubes*
- **Heat Exchanger Maintenance Tools and Products**
- **Condenser Tube Inserts**
- **Accessories** *for boiler erection and maintenance*

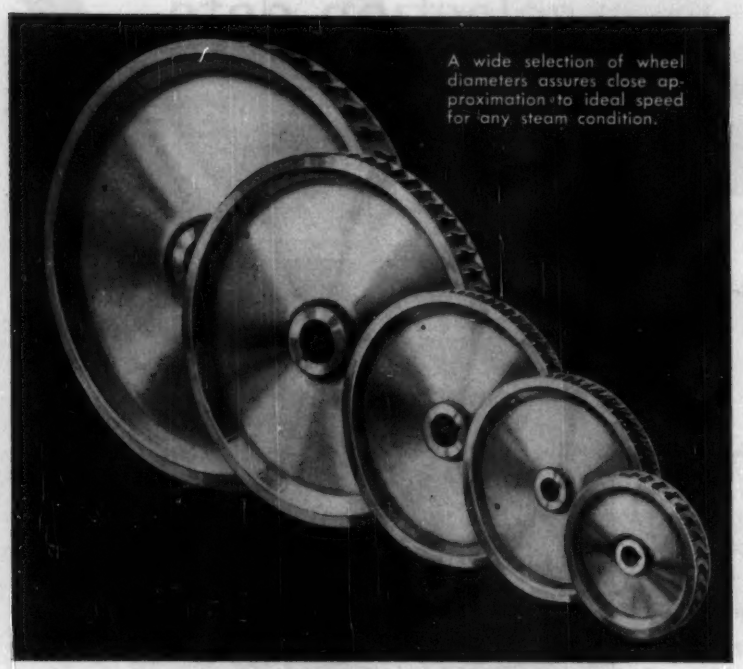
THOMAS C. WILSON, INC.

21-11 44th Avenue, Long Island City 1, New York • Representatives in all principal cities

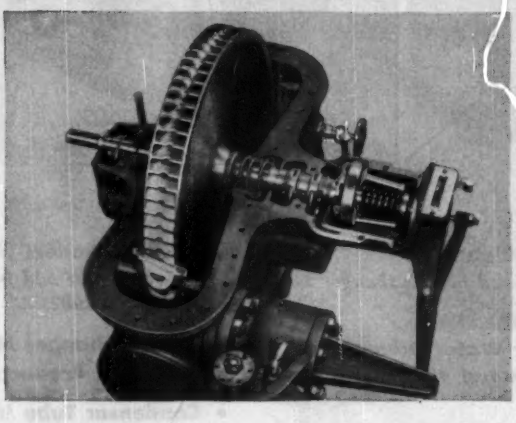
TW865

There's a TERRY wheel turbine to meet your specific needs!

SOLID-WHEEL DURABILITY COMES IN ALL SIZES...



A wide selection of wheel diameters assures close approximation to ideal speed for any steam condition.



Terry wheel turbine with cover removed to show the solid wheel. There are no separate parts to loosen or work out. Blade clearances are generous.

up to 2000 HP

Wherever you need dependable turbine drive up to 2000 HP—and strength and durability are major factors—Terry solid-wheel turbines are specifically equipped for the job. For, within their simple, sturdy casing is a rugged one-piece wheel.

You choose from a broad selection of sizes for all mechanical drive applications—with each Terry wheel turbine accurately proportioned to fit the operating conditions. From the smallest to the largest, these rugged turbines have:

- Solid one-piece wheel.
- Large radial and axial clearances.
- Double rim protected blading.
- Individual nozzle control.
- Dependable and durable governor.
- Heavy dust-proof bearing and governor housing.
- Independent overspeed trip with separate valve.
- Sturdy casing design.
- Strong and easily inspected steam strainer.
- Truly accessible construction, which makes inspection of the interior parts a simple matter.

For full details, send for a copy of bulletin S-116.

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

TERRY

TT-1208

STRONGER and SAFER for every high pressure pipeline duty...

...because they are drop forged by Vogt

Send for Catalog F-9

Constantly imitated but never duplicated, Vogt drop forged steel fittings and flanges have unmatched strength and toughness for your most severe pipeline duties. Laboratory controlled materials and Vogt's special forging techniques assure products which are always uniform in structure, fine grained, and free from porosity. Thereby the shocks and stresses imposed by high pressures and high temperatures are easily withstood, and with stubborn resistance to erosion and corrosion. Consult Catalog F-9 for our complete line of fittings and flanges.

For a copy of Vogt Catalog F-9 address Dept. 24A-FPR.

HENRY VOGT MACHINE CO., P.O. BOX 1918, LOUISVILLE 1, KENTUCKY

SALES OFFICES: New York, Chicago, Cleveland, Dallas, Camden, N. J. St. Louis, Charleston, W. Va., Cincinnati

OTHER VOGT PRODUCTS

Drop Forged Steel Valves — Petroleum Refinery and Chemical Plant Equipment — Steam Generators — Heat Exchangers — Ice Making and Refrigerating Equipment.

Vogt

DROP FORGED STEEL

Fittings and Flanges

For more data on advertised products, use Readers' Service Cards, last page.

the SHORTEST distance

Let Treco show you how short the distance from the ground breaking ceremony to "on stream" can be.

The REFINERY ENGINEERING Company's reputation for fast design, engineering and construction has been built upon the knowledge of how to speed up all operations through careful planning, without sacrificing quality. This is due, in a large degree, to actual refinery-operation experience of Treco's top men. This experience enables Treco to quickly analyze the problem from actual day-to-day contact and to come up with the right answer.

In addition to the constant use of commercial airlines, Treco uses its own stable of planes for the fast movement of staff engineers, who carefully make regular checks of all construction operations. The location of Treco's home office, in the center of the nation, also adds to the efficiency of operation.

On your next job, before the planning stage . . .

....talk with the TRECO man.....

To better serve our customers in the East, Treco has opened a district office at 10 Rockefeller Plaza, N.Y.
Henry T. Fielding
Manager
Telephone
Circle 7-2361

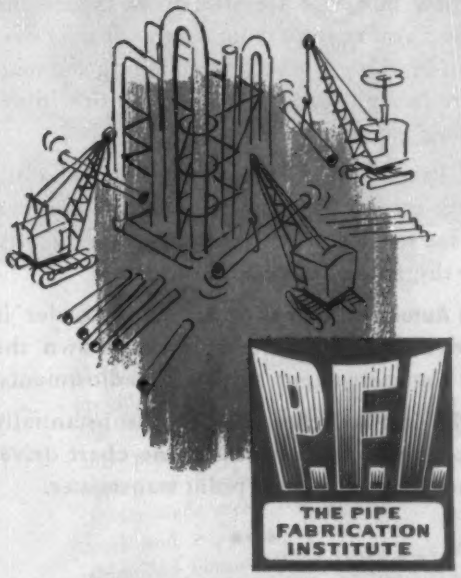
TRECO

A DIVISION of VITRO CORPORATION of AMERICA

The REFINERY ENGINEERING Company

FARMINGTON NEW YORK TULSA TORONTO

"QUICK . . . HAND ME MY P.F.I. Standards"



The gent in the helicopter would really be "up-in-the-air" if he couldn't find his P.F.I. Standards.

Experience has taught him that the use of P.F.I. Standards saves time and money in the design, particularly in the fabrication and erection of high pressure—high temperature piping.

These standards, compiled by the Engineering Standards and Metallurgical Committees, are daily proving their worth from the design-drawing board stage through to final application of prefabricated piping in many types of industries.

Write for all ten P.F.I. Standards or indicate in the coupon below which ones could be helpful in your particular field.

THE PIPE FABRICATION INSTITUTE

Devoted to the Technical and Economic Problems in Piping

ONE GATEWAY CENTER, PITTSBURGH 22, PA.

1 Machining Backing Rings for Butt Welds
2 Dimensioning Welded Assemblies
3 Linear Tolerances, Bending Radii
4 Shop Hydrostatic Testing
5 Cleaning Fabricated Piping
6 Built-up Weld Metal Bosses
7 Welded Nozzles—Spacing
8 Preheat-Postheat Before, After Welding
9 Arc-Welding Dissimilar Ferritic Steels
10 Stress Relieving Practices

Please send me the P.F.I. Standards indicated
1 2 3 4 5 6 7 8 9 10

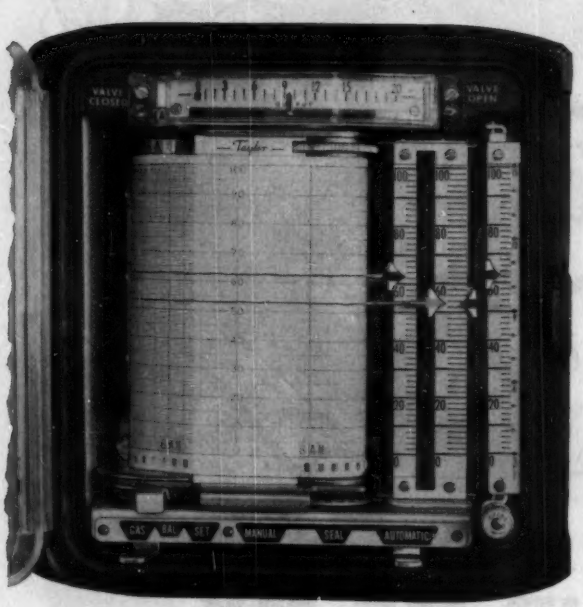
Name_____

Company_____

Address_____ City_____ State_____

For more data on advertised products, use Readers' Service Cards, last page.

Complete Cascade System in ½ Normal Space ...Costs Substantially Reduced



Taylor's New TRANSCOPE Plug-in Recorder provides a complete Cascade System . . . in half the space required by other systems*

Never before has a complete cascade system been available in one recorder case in a 6" panel cut-out.

Complete Cascade System. All switches in one case. Operator performs all start-up and shut-down operations in one recorder. No external switches or relays. No extra space needed. Cascade set point always in view.

All Functions in One Case. Master and secondary variables continuously recorded. Master and secondary controller outputs, as well as set points, continuously indicated.

Unique, New Bumpless Transfer. New switching system lets you change from *control by secondary* to *control by master,* precisely matching the master output to the secondary control point without comparing gages.

Front of Panel Control Settings let you make adjustments easier, quicker and better! You can clearly see what you are doing, and the results, because the record is continuous.

Stays on Automatic Control while the recorder is removed. There's no need to shut down the process for instrument service or adjustments.

Substantial Cost Reduction. You save substantially since you need only one case, one chart drive, one panel cut-out, one set point transmitter.

★ ★ ★

For further information about this revolutionary new Recorder, see your Taylor Field Engineer, or write for **Bulletin 98286.** Taylor Instrument Companies, Rochester, N.Y., Toronto, Ontario.

*Trade-Mark

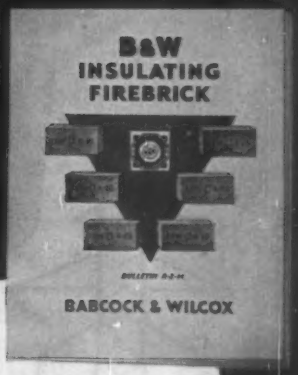
CASE MATES!

The Taylor TRANSCOPE Controller and Recorder are companion plug-in instruments. Together they give new standards of process control performance... unprecedented stability, accuracy and adaptability. Especially suited for the short spans of measurement encountered in present day processing. The TRANSCOPE Controller is insensitive to ambient temperatures, and highly resistant to mechanical shock. Write for **Bulletin 98278.**

Taylor Instruments **MEAN ACCURACY FIRST**

Why B&W IFB for Oil Heater Linings ?

- Lightest weight
- Simplified construction
- High hot load strength
- Lower conductivity
- Lower heat storage
- Better process control



The light weight of B&W Insulating Firebrick provides savings in capital investment in several different ways. The light weight of B&W IFB permits thinner wall constructions of equivalent insulating value. These thinner, lighter walls mean real savings in structural steel and concrete. Construction is further simplified because B&W IFB's high hot load strength makes possible higher unsupported walls without deformation at furnace operating temperatures. In addition B&W IFB can be cut and shaped with ordinary wood working tools, simplifying field installation.

The light weight of B&W Insulating Firebrick also provides the greatest insulation. Thus, they save more fuel.

Light weight also means lower heat storage. B&W IFB protect you against burn-out of expensive alloy tubing in the event of forced shutdown. B&W IFB respond faster to changes in firing rate, too, assuring you of more positive process control.

******Write for Bulletin R-2-H giving more data on B&W Insulating Firebrick.*

BABCOCK & WILCOX
THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42nd ST., NEW YORK 17, N.Y.
WORKS: AUGUSTA, GA.

B&W REFRACTORIES PRODUCTS:
B&W Allmul Firebrick • B&W 80 Firebrick • B&W Junior Firebrick
B&W Insulating Firebrick • B&W Refractory Castables, Plastics and Mortars • B&W Silicon Carbide • B&W Ramming Mixes • B&W Kaowool

R-557

You can do it CHEAPER with UTILITY Electric Power

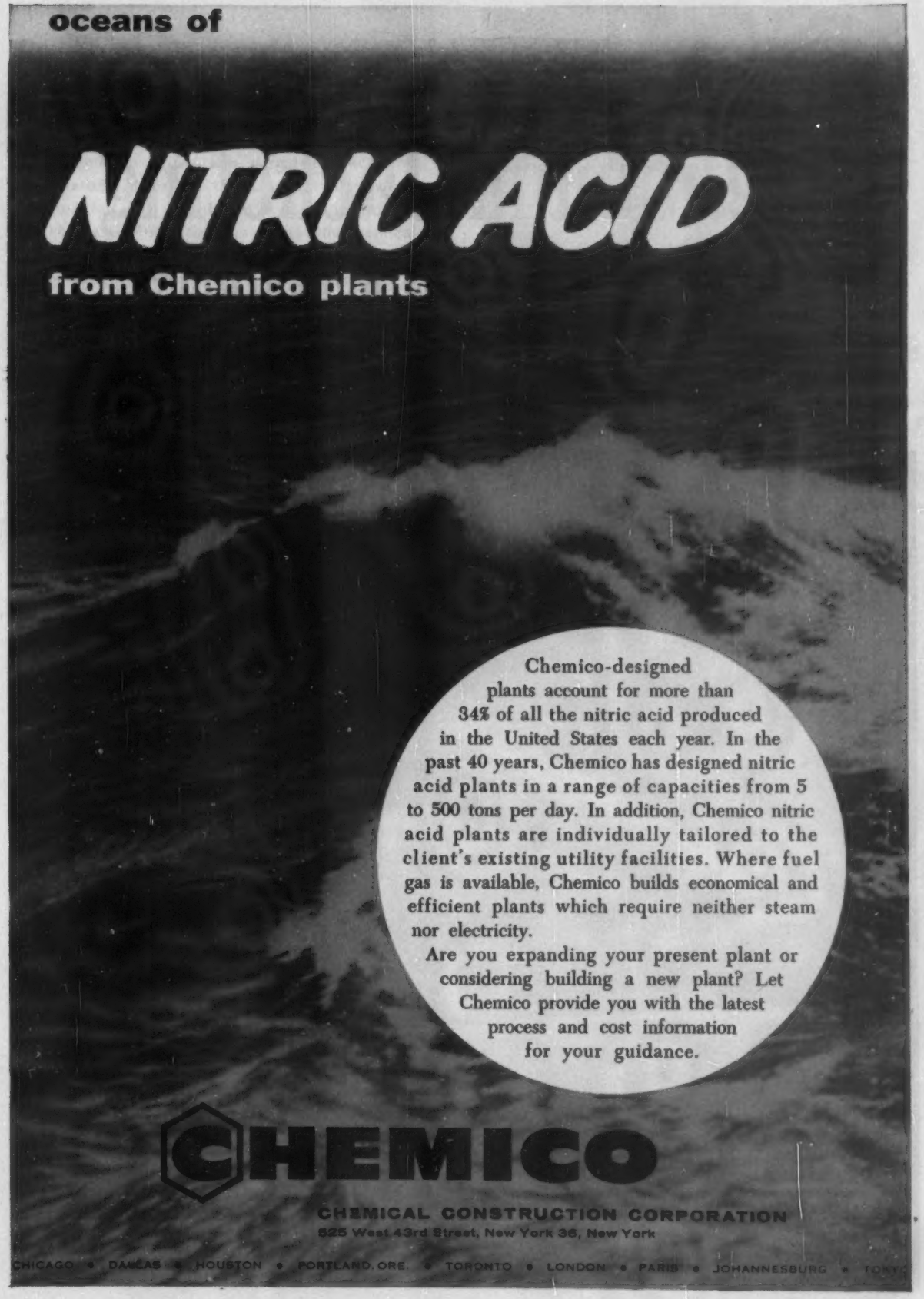
Low Cost. Trouble-free. Efficient Power...

That's Utility Electric Power... modern, dependable and automatically controlled ... operating, with less attention, less maintenance, and with less over-all operating costs, at refineries, petrochemical plants, on pipelines and production units, etc. Plan now to make the switch to Utility Electric Power. You'll be glad you did.

Petroleum Electric Power Association

P. O. BOX 2771, DALLAS, TEXAS

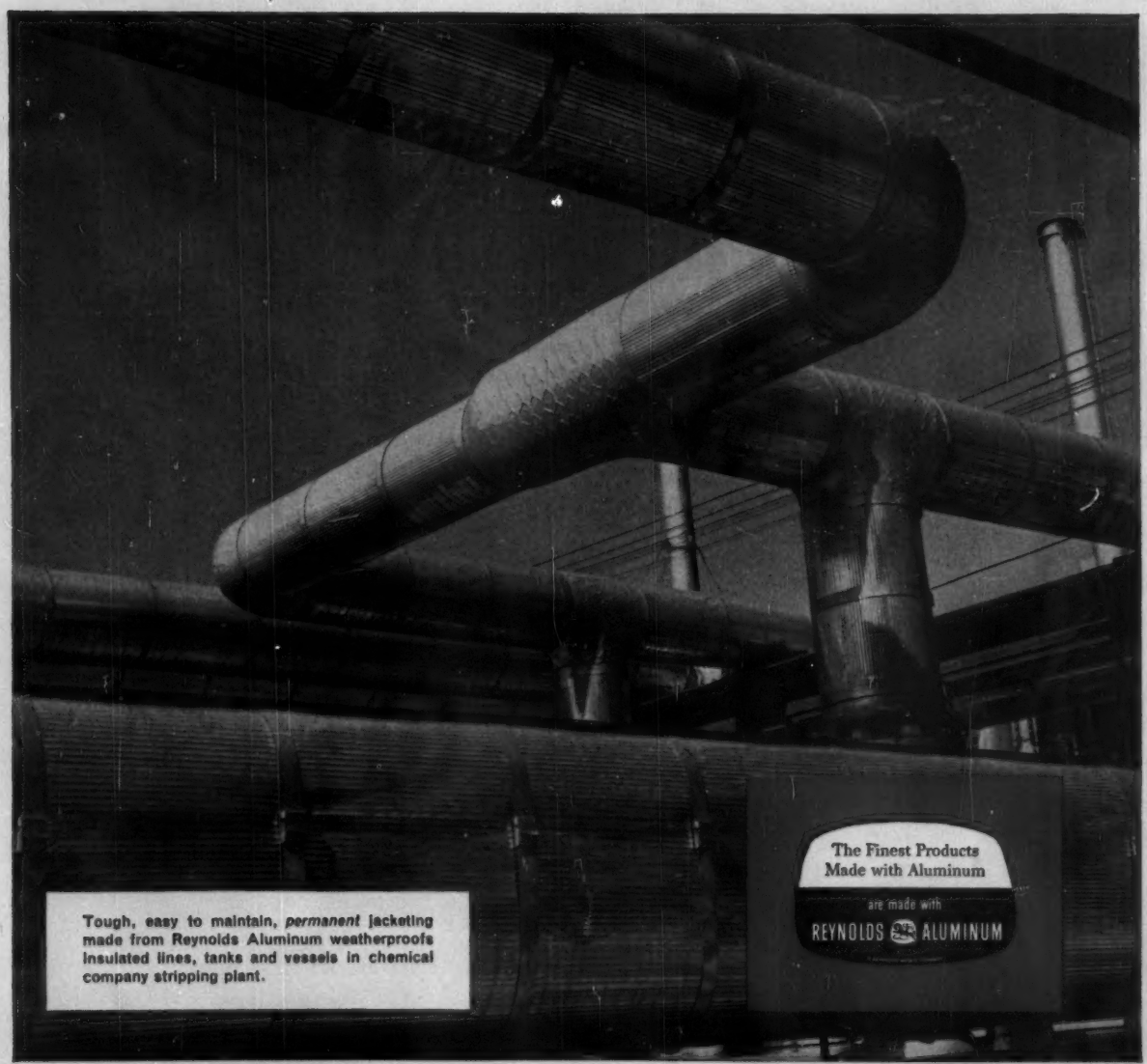
ORGANIZED IN THE INTEREST OF GREATER SERVICE TO THE PETROLEUM INDUSTRY


oceans of
NITRIC ACID
from Chemico plants
Chemico-designed plants account for more than 34% of all the nitric acid produced in the United States each year. In the past 40 years, Chemico has designed nitric acid plants in a range of capacities from 5 to 500 tons per day. In addition, Chemico nitric acid plants are individually tailored to the client's existing utility facilities. Where fuel gas is available, Chemico builds economical and efficient plants which require neither steam nor electricity.
Are you expanding your present plant or considering building a new plant? Let Chemico provide you with the latest process and cost information for your guidance.
CHEMICO
CHEMICAL CONSTRUCTION CORPORATION
525 West 43rd Street, New York 36, New York
CHICAGO • DALLAS • HOUSTON • PORTLAND, ORE. • TORONTO • LONDON • PARIS • JOHANNESBURG • TOKYO

For more data on advertised products, use Readers' Service Cards, last page.

Aluminum Jacketing

...how it improves appearance, cuts installation, maintenance costs



Tough, easy to maintain, *permanent* jacketing made from Reynolds Aluminum weatherproofs insulated lines, tanks and vessels in chemical company stripping plant.

For more data on advertised products, use Readers' Service Cards, last page.

Aluminum is the one permanent jacketing material, a material that stays clean and new-looking with a minimum of upkeep. And that holds true in the toughest jobs in the chemical and petroleum processing industry. Jacketing made from Reynolds Aluminum cuts costs in many other ways, too. Here's how:

CORROSION-RESISTANCE

Many industrial atmospheres, chemicals, gases and contaminants literally eat jacketing materials away. But they don't bother aluminum. Reynolds Aluminum Jacketing stays strong, clean and rust-free in the most corrosive atmospheres, handling the most corrosive materials, in any climate or weather condition. *And it needs no repetitive maintenance.*

EASY TO INSTALL

Lightweight aluminum is one of the most workable, formable of metals. That means faster, easier installation, and less time and labor on the site. You can cut and shape Reynolds Aluminum Jacketing with ordinary hand tools, and can use larger sheets because it is so light. Weighing only ⅓ as much as steel—or less—aluminum jacketing can save in shipping, handling, installation and supporting structure costs.

GOOD INSULATION PROPERTIES

Aluminum jacketing has a low factor of emissivity—it keeps heat *inside*—a big added advantage when you're handling or storing hot fluids. Then too, aluminum reflects as much as 95% of radiant heat. That means it protects volatile products from costly evaporation losses.

NON-SPARKING

Flammable and explosive materials are safer when aluminum is used for jacketing or handling equipment, because aluminum is non-sparking and won't burn.

Suntide Refining Co. tower in platforming and rexforming unit—jacketed in Reynolds Aluminum.

Of course, aluminum's properties are important to chemical and petroleum processing men in other applications as well as jacketing. In process pipe, for example, or oil country pipe, where Reynolds Aluminum's light weight and weldability saves hundreds of man-hours on installation. Tanks and vessels, heat exchangers, drilling rigs and offshore rigs are all using more and more aluminum, too.

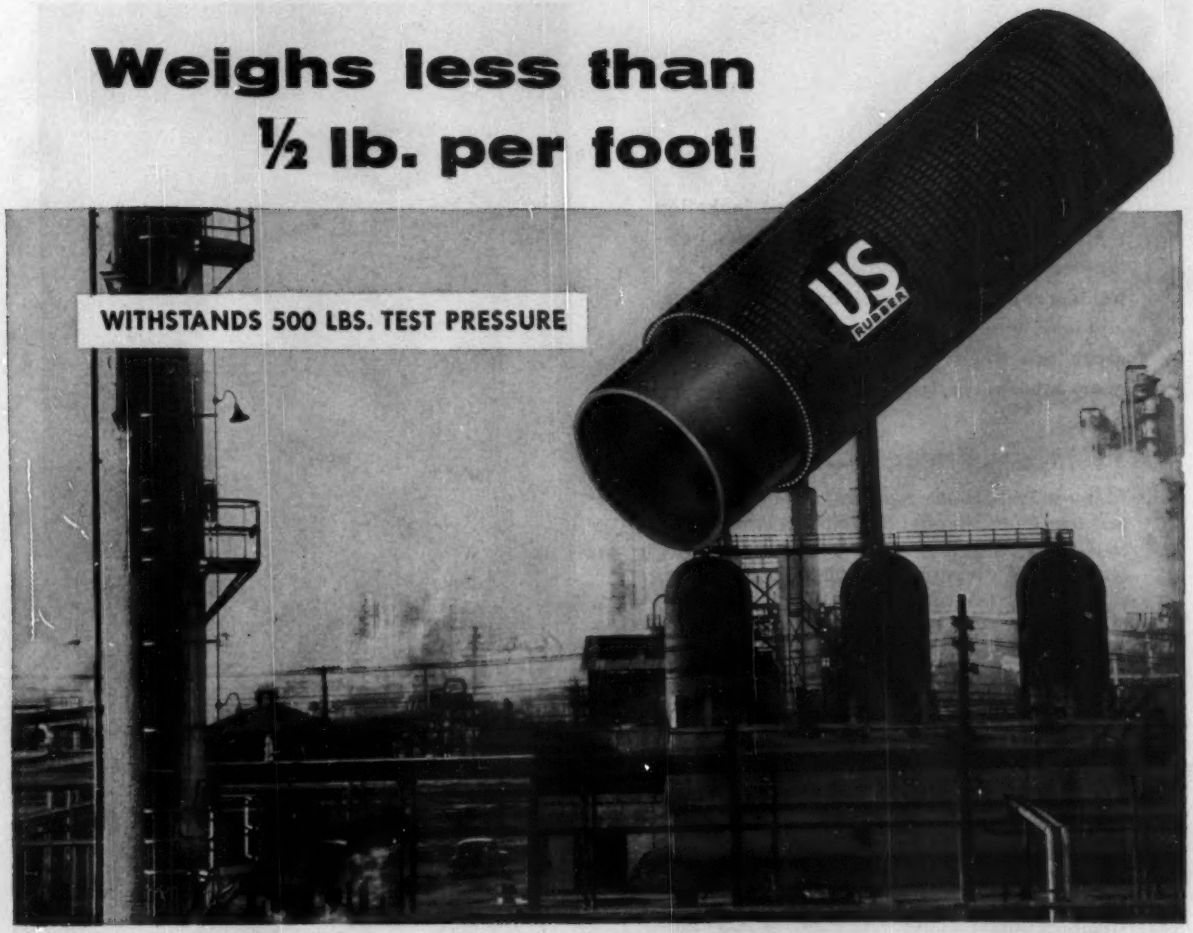
For details on how Reynolds Aluminum can help you, or for technical service, call your local Reynolds office or write *Reynolds Metals Company, P.O. Box 2346-CT, Richmond 18, Virginia; International Division, 19 East 47th Street, New York 17, New York.*

REYNOLDS ALUMINUM

Watch Reynolds All-Family Television Program "DISNEYLAND", ABC-TV.

For more data on advertised products, use Readers' Service Cards, last page.

Weighs less than ½ lb. per foot!



The super-flexible *All-Dacron*

U.S. FLEXLITE® FIRE HOSE!

Its single jacket is all Dacron*—to give the lighter weight, pressure resistance, flexibility, rackability required by today's petro-chemical fire departments.

Although U.S. Flexlite weighs 50% less than conventional hose, it will handle extreme pressures! Its Neoprene tube and Dacron jacket have the required resistance to chemicals, petroleum, mildew, dampness, heat. Coils easily, dries fast. United States Rubber Company also makes the following hose for the petro-chemical field.

(1) "Reliance®" Double Jacket Dacron reinforced (weighs 50 lbs. per 100 ft.) (withstands 400 lbs. test pressure)

(2) "Reliance" Double Jacket Dacron reinforced (weighs 54 lbs. per 100 ft.) (withstands 600 lbs. test pressure)

(3) U. S. Matchless® Carbolized—most rugged hose in the market.

Obtainable at any of the 28 "U. S." District Offices, at selected distributors, or write us at Rockefeller Center, New York 20, N. Y. In Canada, Dominion Rubber Co., Ltd.

*DuPont's polyester fiber

US RUBBER

Mechanical Goods Division

United States Rubber

MAJOR SOURCE OF MAJOR ACIDS

SULFURIC ACID

Commercial Grades of 77.67 to 122.5% H_2SO_4. *"Special Grade"* concentrations of 93 to 100% H_2SO_4 with iron guaranteed less than 50 ppm and similarly low content of nitrogen, arsenic and other impurities. *Electrolyte Quality* at Sp.Gr. 1.300, 1.360, 1.400, 1.500 and 1.835. *Oleum* in all concentrations from 15% free SO_3 to 100% Liquid SO_3 (equivalent to 103.38 to 122.5% H_2SO_4). *Regenerated* Acid sludges are decomposed, regenerated and delivered as water-white 98% H_2SO_4 on an established contract basis. *Spent Acids* from the manufacture of white oils, fuels, chlorine gas, alcohols, DDT, butadiene and other products are recovered, regenerated or fortified for re-use at the source or for different use. In any case, Stauffer processing and contract arrangements eliminate waste, eliminate air and stream pollution or the alternative of in-plant conversion of process residues.

MURIATIC ACID

Delivered in standard strengths of 18°, 20° and 22° Bé corresponding to 27.92, 31.45 and 35.21% HCl. Stauffer also offers an extremely high-purity, high-analysis grade of muriatic acid for special uses. All grades are available in tank cars, tank trucks and carboys.

NITRIC ACID

Commercial Grades of 38°, 40° and 42° Bé corresponding to 56.52, 61.38 and 67.18% HNO_3. *Engravers' Quality* of the same concentrations is conditioned to prevent fuming and discoloration of etching plates.

HYDROFLUORIC ACID

Anhydrous, is shipped in 22-ton and 42-ton tank cars, and in 100- and 200-pound cylinders from the Nyotex Chemicals Division of Stauffer Chemical Company at Houston; aqueous acid from the Stauffer plant at Louisville, Ky.

80 YEARS OF SERVICE TO INDUSTRY
testify to Stauffer Chemical Company's reliability as a major source of volume acids and an authoritative source of information on their use and handling.

Stauffer CHEMICALS SINCE 1885

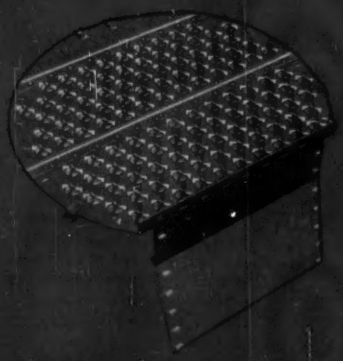
STAUFFER CHEMICAL COMPANY

380 Madison Avenue, New York 17, New York
636 California Street, San Francisco 8, California
Consolidated Chemical Division: 6910 Fannin Street, Houston, Texas

Stauffer's Sulfuric Acid is shipped from Mobile, Ala., Los Angeles and Richmond, Cal., Hammond, Ind., Baton Rouge, La., Baytown, Fort Worth and Houston, Tex., and various stock points. Hydrochloric Acid is shipped from Richmond, Cal., and Fort Worth; Hydrofluoric Acid (anhydrous) from Houston; (aqueous) from Louisville.

For more data on advertised products, use Readers' Service Cards, last page.

AGAINST JUNK PILES LIKE THIS!



KOCH

ENGINEERING COMPANY, INC.

321 West Douglas Avenue, Wichita 2, Kansas

Continuing progress through research

Guard against that rainy day when obsolete trays must be junked — because higher capacities are required . . .

GIVE FLEXITRAYS A TRIAL TODAY!

More than 700 towers — in all services — are now equipped with these high-capacity, extremely flexible trays. Lower priced Flexitrays prevent expensive — unnecessary — replacements when higher capacities become a necessity.

Don't be caught in a deluge of "yesterday's" obsolete equipment — give Flexitrays a try, today! Write, wire, or phone your nearest Koch Representative. He has the Flexitray application to YOUR problem.

REPRESENTATIVES

Butte, Montana, P. O. Box 208, G. M. Wallace & Co., 2-8391
Denver, Colorado, 324 Denham Bldg., G. M. Wallace & Co., AM 6-0386
Houston, Texas, P. O. Box 12371, Alpha Engineering Co., MI 9-8071
Kansas City 13, Mo., P. O. Box 7061, Sample Brothers, DE 3-2612
New York 17, N. Y., 60 East 42nd St., F. J. McConnell Co., YU 6-7266
Oakland, Calif., 600 Sixteenth St., Engineered Process Equip. Co., TE 2-5391
Park Ridge, Illinois, 1521 Courtland Ave., M. B. Fisher, TA 3-6495
Pasadena, Calif., 774 East Green St., Engineered Process Equip. Co., RY 1-6663
Pittsburgh 19, Pa., 501 Alcoa Building, D. D. Foster Co., AT 1-0865
Salt Lake City, Utah, Continental Bank Bldg., G. M. Wallace & Co., EM 4-5611
South Charleston, W. Va., 411 "D" Street, D. D. Foster Co., Rt 4-9446
St. Louis 17, Mo., 2010 Big Bend Blvd., Sample Brothers, ST 1-7941
Tulsa, Oklahoma, Wright Building, W. C. Myers Co., LU 4-7264

ACTUAL SIZE

GET THE MOST FOR YOUR

BTU DOLLAR

...with Nicholson steam traps

You get top operating temperature per dollar of fuel consumption . . . when you use the Nicholson steam trap. This trap purges all air and non-condensibles from pipes and equipment *continuously* . . . not just at warm-up time. Your boiler doesn't have to operate at top capacity —all the time—to obtain top steam temperature where and when you need it.

Make full use of your BTU dollar, with Nicholson traps. They have only one moving part . . . a valve that operates on just a few degrees of temperature differential.

In your steam generation, and in your steam utilization . . . Nicholson traps will save you money. You can try one . . . without obligation! W. H. Nicholson and Company, 12 Oregon St., Wilkes-Barre, Pa. Sales and Engineering Offices in 98 principal cities.

NICHOLSON

of Wilkes-Barre

For more data on advertised products, use Readers' Service Cards, last page.

HUDSON Combin-aire

LOW TEMPERATURE COOLING USING COMBINATION OF MINIMUM WATER AND MAXIMUM AIR

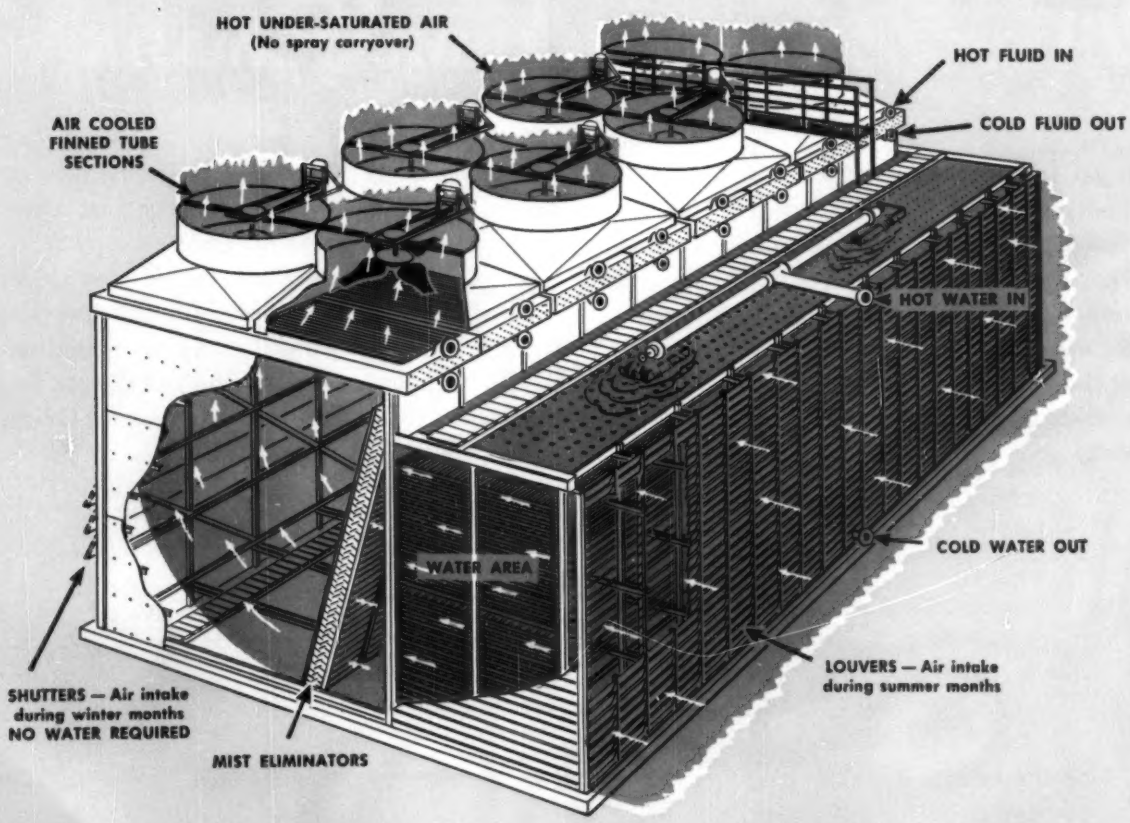
In recent years Hudson Solo-aire cooling in which only air is used as a cooling medium has been installed by the world's largest refineries. In recent cases of three separate 40,000 barrel complete refineries in locations where unlimited water is accessible Hudson Solo-aires are used for *all* process cooling.

So that air could be used for cooling those process streams requiring lower terminal temperatures than obtainable with ambient summer air temperatures, Hudson developed and in 1949 installed the first Combin-aire cooling unit. Since that time Combin-aires have proven their worth in installations for over 80 services in major refineries, chemical plants and gas processing plants in the United States, the Middle East, Europe, Mexico and South America.

In Combin-aire cooling, high temperature ambient air is first pre-cooled by direct contact with water, the cooled air then becoming the low temperature cooling medium for fin-tube elements. Cooling of air, and subsequent use of the cooled air for fin-tube cooling of process streams, are effected in one integrated structure — the Combin-aire.

Cooling with Combin-aire to overcome the occasional limitation of high ambient temperatures has the following advantages:

- **Absolute minimum water consumption consistent with attainment of low terminal process stream temperatures.**
- **Water circulation may be made automatically responsive to air temperatures with no water circulated except at high ambient temperature.**
- **No water treatment necessary. Salt water or brackish water may be used.**
- **No spray carryover or condensation. After passing across the fin-tube elements the heated air leaving the Combin-aire at elevated temperature is undersaturated with water vapor and cannot precipitate condensate or carry water spray.**
- **Minimum piping. Combin-aire may be installed immediately adjacent to other process equipment.**
- **Clean air to fin-tube units. During the hot season water is washed, removing dust, sand and insects.**


HOT UNDER-SATURATED AIR
(No spray carryover)
HOT FLUID IN
COLD FLUID OUT
AIR COOLED FINNED TUBE SECTIONS
HOT WATER IN
WATER AREA
COLD WATER OUT
LOUVERS — Air intake during summer months
SHUTTERS — Air intake during winter months NO WATER REQUIRED
MIST ELIMINATORS

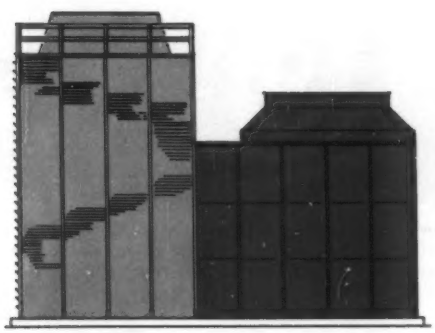
When Combin-aires are installed as adjuncts to cooling systems using existing shell and tube or other water cooled equipment the cooled water from the bottom of the Combin-aire may be used in such equipment. The Combin-aire then takes on the additional function of a water cooling tower with, however, the advantages over conventional cooling towers of dual use of both air and water and elimination of water spray carryover and condensate precipitation.

In over 80 services and under a wide range of atmospheric operating conditions Combin-aire units have amply fulfilled performance and mechanical specifications. Before proceeding with a new process unit or revamping or adding to present cooling systems let Hudson give objective assistance in determining the most economic balance in the use of air cooling, Combin-aire cooling and water cooling.

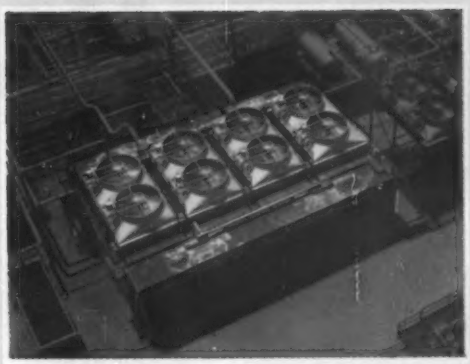
CONVERTING COOLING TOWERS INTO COMBIN-AIRE UNITS

Presently installed cooling towers may be used as the basis for Combin-aire cooling by installing structure with fin-tube elements and fans immediately adjacent to the cooling tower with air for the fin-tube elements being drawn across the water near the bottom of the cooling tower, thus increasing the capacity of the cooling tower, and cooling the air for use in the fin-tube elements.

EXISTING COOLING TOWER **COMBIN-AIRE ADDITION**

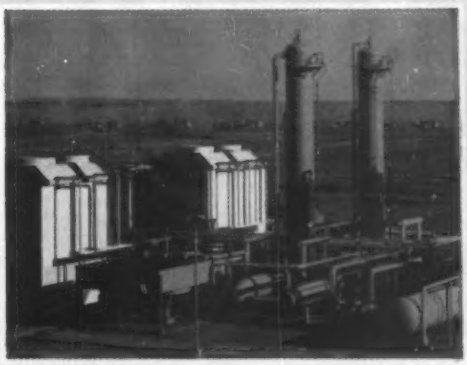


Combin-aire is protected by U. S. Patents, Patents pending and copyrights.



TEXAS —
COSDEN PETROLEUM CORPORATION
Big Spring, Texas

MEXICO —
PETROLEOS MEXICANOS
Reynosa, Tamaulipas, Mexico

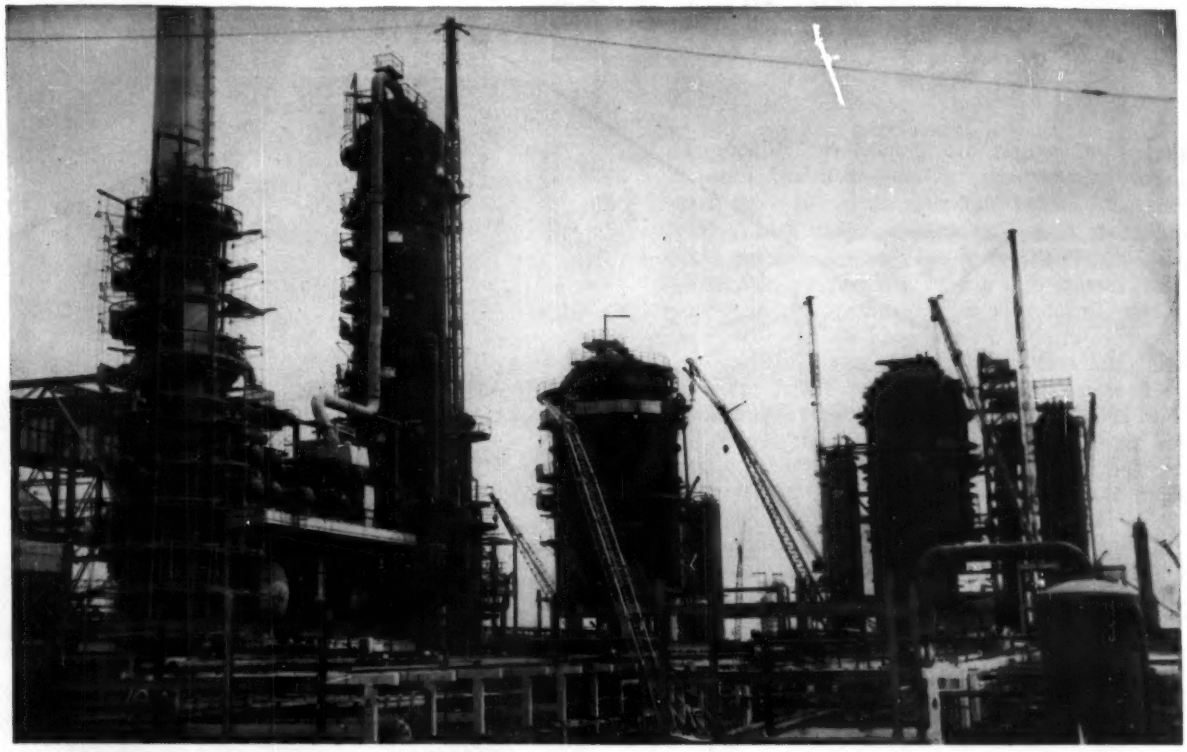


PAKISTAN —
PAKISTAN PETROLEUM, LTD.
Sui gas field, West Pakistan

HUDSON
ENGINEERING CORPORATION
FAIRVIEW STATION • HOUSTON, TEXAS

SALES OFFICES:
9935 Santa Monica Blvd. Beverly Hills, California • 122 East 42nd St. New York, 17, N. Y. • 199 Bay Street Toronto, Ontario, Canada
17 Stratton St., Picadilly London W. 1, England • Corrientes 1115 Buenos Aires, Argen. • Rua Mexico 45 Rio de Janeiro, Brazil

HUDSON COOLING EQUIPMENT MANUFACTURED UNDER LICENSE BY:
A. F. Craig & Co., Ltd. Paisley, Scotland • Batignolles-Chatillon 5 Rue de Monttessuy Paris, France



A dozen vessels built by Newport News were furnished under contract with C. F. Braun, Inc., of Alhambra, Calif., design engineers for the ultra-modern Delaware Flying A Refinery of the Tidewater Oil Company located 15 miles south of Wilmington.

Newport News builds 12 major components for new Flying A 130,000-bpd refinery

This is the Tidewater Delaware Flying A Refinery while under construction near Wilmington.

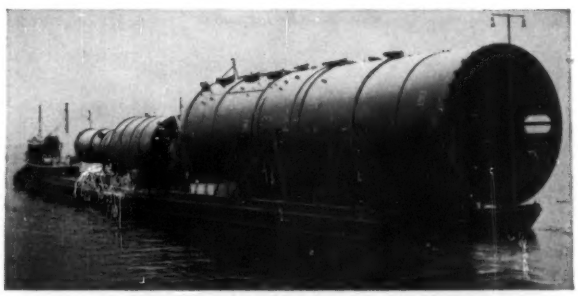
Newport News fabricated 12 of its major vessels — 2 of which are the largest such units ever built: a 250′ Orthoflow fluid "cat cracker" converter and a 225′ reactor scrubber of the fluid coker.

More notable than size, though, is the quality of the Newport News fabrication.

Coke-out screens in the reactor scrubber, for example, are made of 704 12% chromium segments. Welded together with accuracy, they provide 45% clear opening . . . with opening tolerances less than 1%.

You get expert fabrication, the skill of specialists when Newport News builds your equipment. When you want reactors, pressure vessels, vacuum tanks and the like, sub assemblies or weldments in almost any size or shape, get a bid from Newport News.

Send for newly published, easy-to-read, illustrated booklet, "Facilities and Products". It describes the many ways in which Newport News can help you with present or future projects. Write for your copy today.



Full advantage was taken of the Newport News deep water loading facilities for transportation of all of the equipment by barge. Shop erection prior to shipment assured fast, trouble-free field assembly.

Engineers: Desirable positions available at Newport News for Designers and Engineers in many categories. Address inquiries to Employment Manager.

Newport News Shipbuilding and Dry Dock Company, Newport News, Virginia

S VALVES

by CONOFLOW

for the

TOUGH JOBS

SIZES TO 14"
PRESSURE RATINGS TO 2500 LBS.

S valves by Conoflow are on day-in, day-out service handling the tough jobs in many industries. They offer unmatched performance for automatic throttling control of erosive and corrosive slurries, coking oils and liquids, and high pressure pipe line gases, steam and water. **S** valves have proved to be the final answer for such services as alumina refining, pulp mill digester relief, boiler feed water control, and experimental wind tunnels. A few well-known users are: Reynolds Aluminum Co., U. S. Steel, Humble Oil Co., Aluminum Corp. of America, Texas Co., Redstone Arsenal, Knolls Atomic Labs., and Olin-Revere Metals Corp.

The difference is in the design...
The patented, single-seated **S** valve is of heavy, rugged construction throughout. Extra body wall thickness, streamlined contours and heavy stem guiding make the **S** valve especially suited for high pressure drops. Venturi seat ring and parabolic plug assure tight shut-off. Self-sealing bonnet is leakproof. Sizes 1" through 4" carry ASA ratings to 2500 lbs.; sizes 6" and 8" to 1500 lbs. ASA; sizes 10", 12" and 14" to 300 lbs. ASA.

For complete data on S valves write for Bulletin S-1 to Dept. C-803, Conoflow Corporation, 2100 Arch Street, Philadelphia 3, Penna.

Cono-Controls®

CONOFLOW CORPORATION
FOREMOST IN FINAL CONTROL ELEMENTS

A subsidiary of WALWORTH

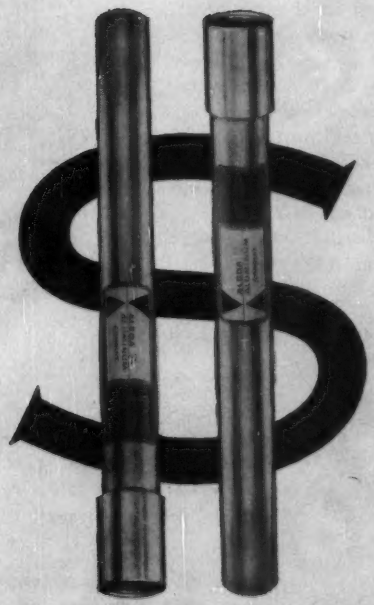
ALCOA ALUMINUM CONDUIT OFFERS NEW ECONOMY FOR ELECTRICAL DISTRIBUTION SYSTEMS. A growing number of consulting engineers, architects and contractors are recommending Alcoa® Aluminum Electrical Rigid Conduit as the ideal way to save electrical distribution dollars and to insure complete dependability. For distribution systems in office buildings, factories, refineries, processing and chemical plants and other new and remodeled structures, corrosion-resistant aluminum conduit has always offered a tremendous bonus in attractive appearance, longer life and maintenance-free operation. Now, lower prices in all sizes have made aluminum competitive with other materials. Aluminum conduit is easier to cut, bend and thread; it is nonstaining without painting; it is nonmagnetic and reduces voltage drop up to 20 per cent. It is nonsparking, lighter in weight and easier to install. It has the approval of Underwriters' Laboratories, Inc. Available for immediate delivery. For more information, contact your nearest Alcoa conduit distributor or Alcoa sales office. Aluminum Company of America, 2335-F Alcoa Building, Pittsburgh 19, Penna.

YOUR GUIDE TO THE BEST IN ALUMINUM VALUE

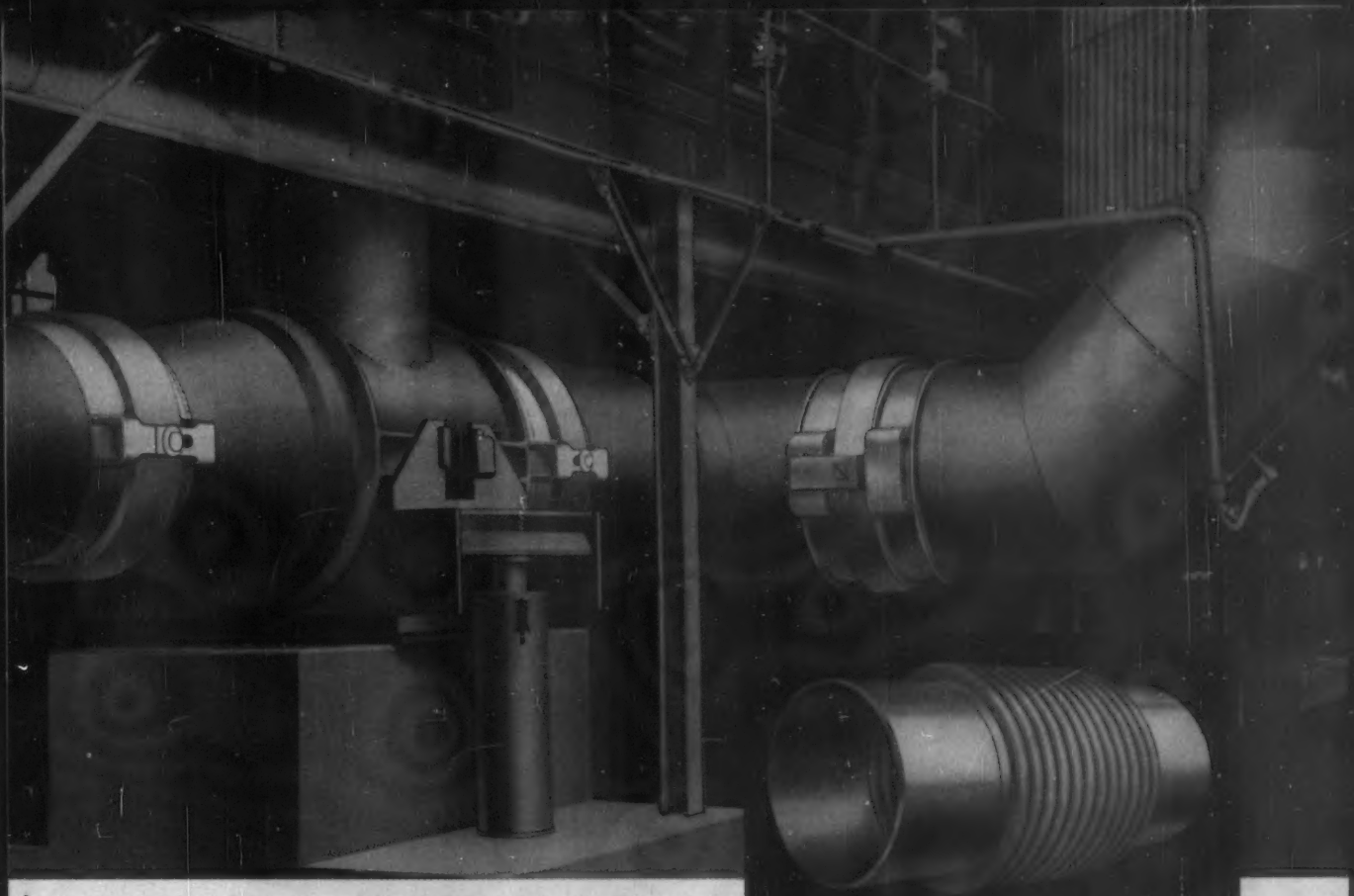
ALCOA ALUMINUM CONDUIT

Underwriters' Laboratories, Inc. INSPECTED RIGID CONDUIT ISSUE MU-28

"ALCOA THEATRE," EXCITING ADVENTURE, ALTERNATE MONDAY EVENINGS



For more data on advertised products, use Readers' Service Cards, last page.



View of hydrocarbon outlet line just below reactors shows three of a total of 67 Badger S-R Expansion Joints at Firestone's new Butadiene Plant at Orange, Texas. Joints shown are equipped with guide bars and external covers.

Series 50W S-R Expansion Joint
Shown with cover removed

Badger S-R Expansion Joints handle rugged 1100° service at Firestone's new plant

The Houdry process used at Firestone Tire and Rubber Company's new Butadiene Plant calls for temperatures up to 1100°. Add critical forces on anchors and connected equipment, wind loading, and complex piping arrangements and you have real problems in piping and expansion joint design.

Working together with Catalytic Construction Co. and Firestone, Badger solved these problems with new Service-Rated (S-R) Expansion Joints. In all, sixty-seven joints have been installed, all of the new Series 50 (low pressure) S-R design. Ranging in size from 30″ to 72″, the joints are arranged singly or in systems of hinged and tandem types to absorb and control pipe line movement (which, due to the piping arrangement, is often axial and lateral — in *two different directions*). Stainless steel bellows are used in all joints; welding nipples are stainless or carbon steel depending on temperatures to be encountered.

Here is another example of a severe pipe expansion problem Badger S-R Expansion Joints and engineering experience have solved successfully. Find out more about the ways they can help you — write today for illustrated brochure.

New corrugation and ring designs produce better equalization, "all-curve" flexing

Curvilinear Corrugations used in S-R Expansion Joints were developed by the Badger Research Department. Under operating pressures (white line) the new design produces more uniform movement per corrugation and natural "all-curve" flexing. Stress is reduced... life increased.

Series 50 corrugation cross-section

S-R Joints for higher pressures have tubular Reinforcing Rings. These new rings make metal-to-metal contact only in the "valley" of each corrugation allowing natural "all-curve" flexing (white line). Tubular shape permits greater effective flexing height which contributes to longer life.

Series 150 corrugation and ring cross-section

BADGER

S R

SERVICE RATED

EXPANSION JOINTS

© 1958 BMC

BADGER MANUFACTURING COMPANY
230 Bent St., Cambridge 41, Mass. • 60 East 42nd St., New York, New York
Representatives in Principal Cities

DE LAVAL CENTRIFUGAL COMPRESSORS

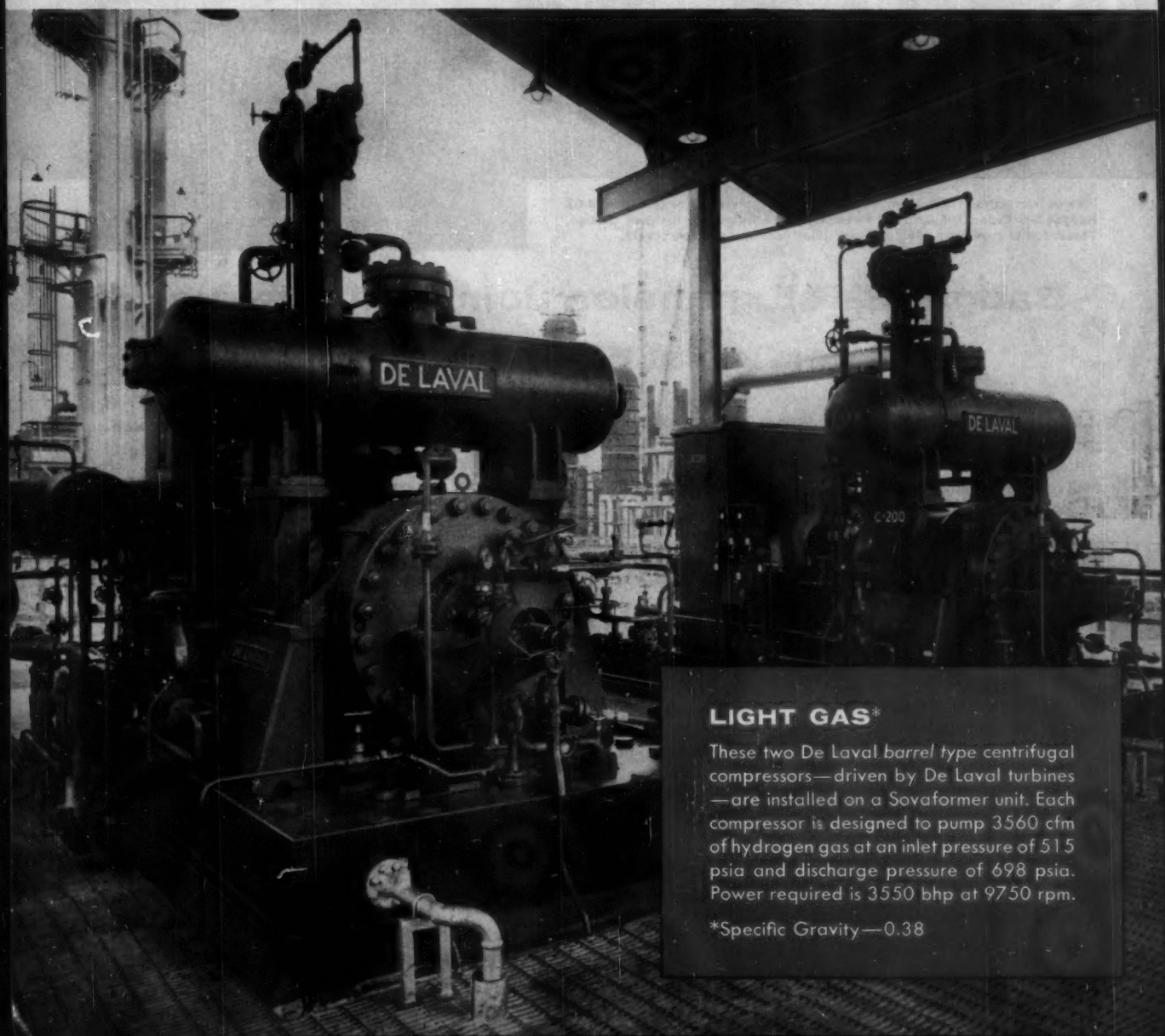
used for light gas, in Magnolia

As part of the expansion program in the Beaumont, Texas refinery of the Magnolia Petroleum Company, De Laval turbine-driven centrifugal compressors are on stream in three important applications:

- **recirculating hydrogen gas in a reforming unit**
- **pumping hydrocarbon gas in a compressor station**
- **supplying combustion air on a giant cat cracker**

Designed and built to perform dependably in heavy-duty continuous operation, De Laval centrifugal compressors are available for every refinery process. Whether you need to handle light or heavy gases at high or low pressures in catalytic cracking, reforming, alkylation, coking or any similar service, it pays to look to De Laval. We can give you the benefit of more than 40 years of experience in solving gas compression problems.

SEND FOR DE LAVAL BULLETIN 0504.

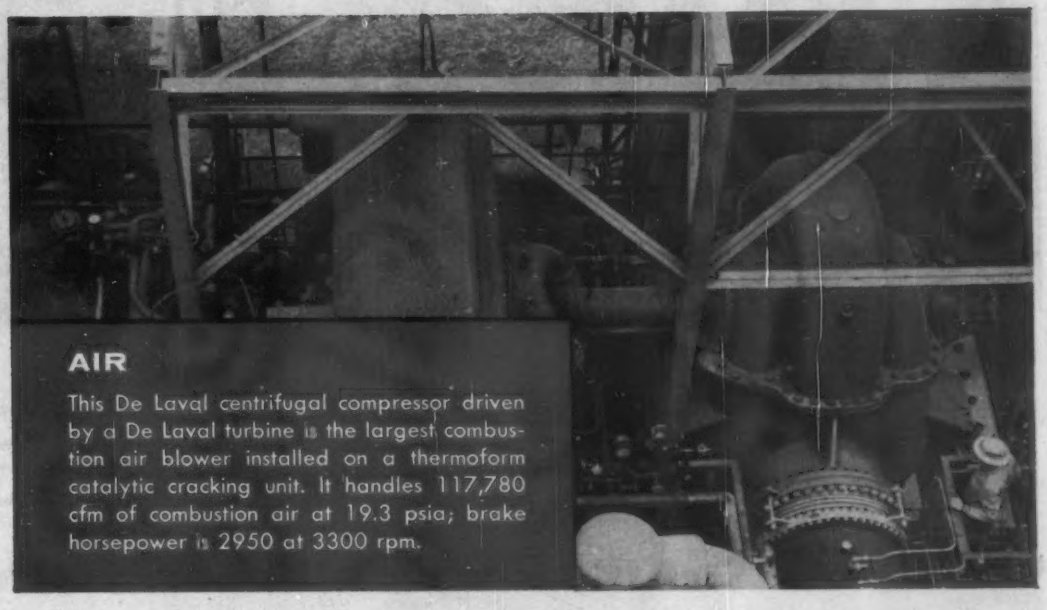


LIGHT GAS*

These two De Laval *barrel type* centrifugal compressors—driven by De Laval turbines—are installed on a Sovaformer unit. Each compressor is designed to pump 3560 cfm of hydrogen gas at an inlet pressure of 515 psia and discharge pressure of 698 psia. Power required is 3550 bhp at 9750 rpm.

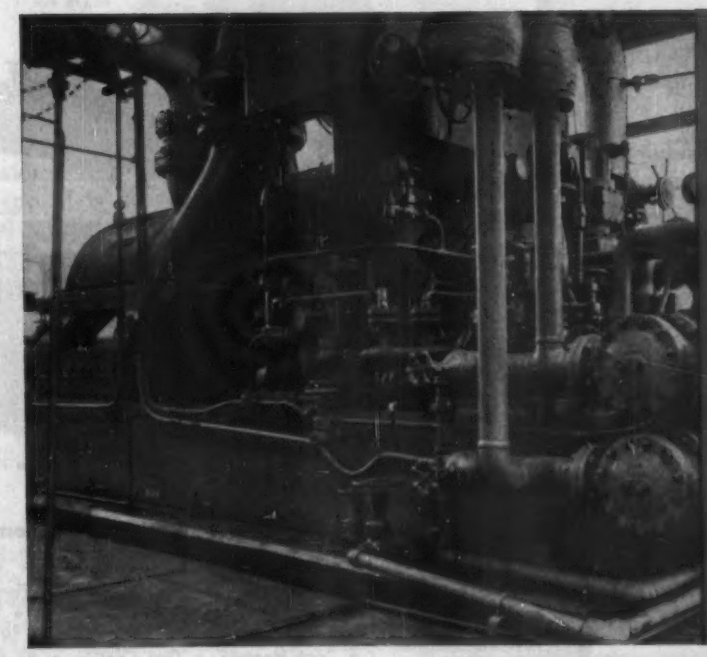
*Specific Gravity—0.38

heavy gas and air handling
Petroleum's expansion program



AIR

This De Laval centrifugal compressor driven by a De Laval turbine is the largest combustion air blower installed on a thermoform catalytic cracking unit. It handles 117,780 cfm of combustion air at 19.3 psia; brake horsepower is 2950 at 3300 rpm.



HEAVY GAS*

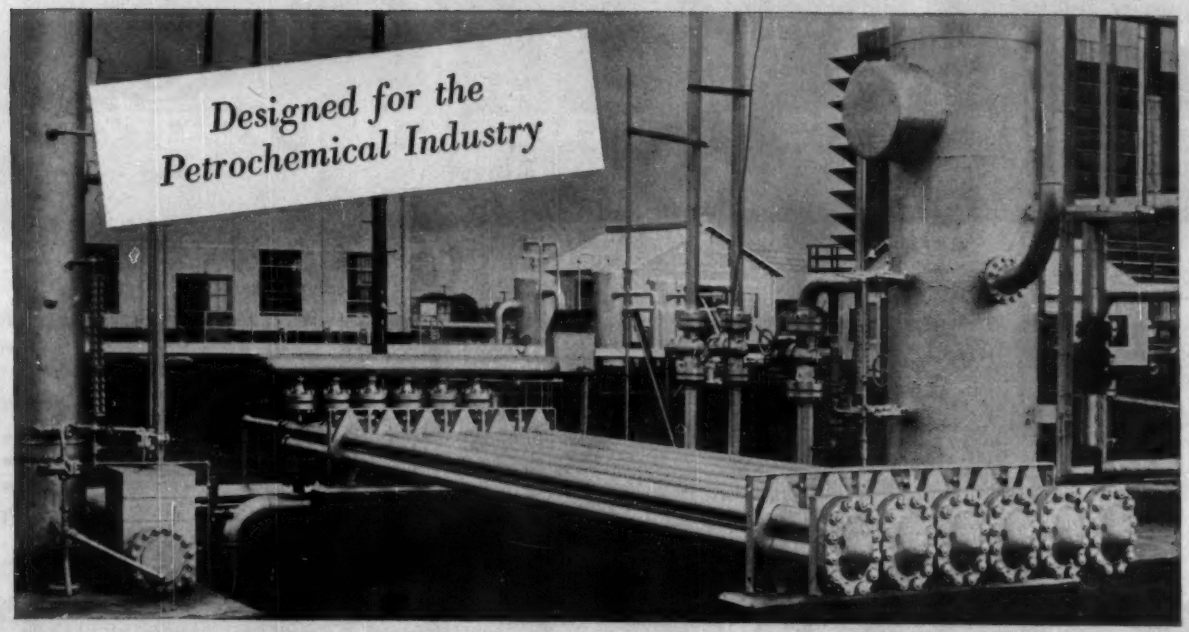
This De Laval centrifugal compressor and turbine installation is located in Magnolia Petroleum's number 1 gas compressor station. The unit is designed to pump 10,560 cfm of hydrocarbon gas at 65.0 psia with a suction pressure of 14.0 psia.

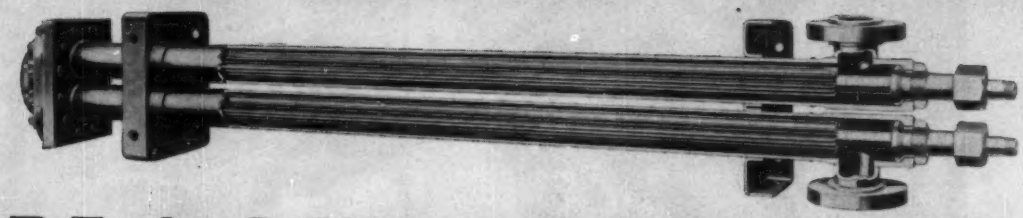
* Specific Gravity—1.376

DE LAVAL *Centrifugal Compressors*

DE LAVAL STEAM TURBINE COMPANY
811 Nottingham Way, Trenton 2, New Jersey

DL-619





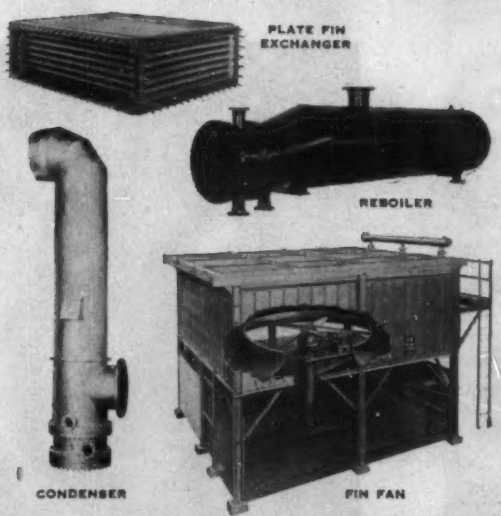
G-R Twin G-Fins...versatile and simple

Griscom-Russell Twin G-Fin Sections are the simplest type of heat exchanger—therefore, they're the easiest to maintain and use.

Their simple construction—a finned tube within another tube—makes their operation foolproof and simplifies repair and cleaning when necessary.

Individual Twin G-Fin Units can be connected in series or parallel in any number required for use as gas or fluid heaters and coolers, reboilers, condensers, and vapor and liquid heat exchangers. Capacity can be easily added or removed and the units can be reused in different services and locations easily.

Send for Griscom-Russell Bulletin 1401R



G-R Designed for the Petrochemical Field

Reboilers • Fin Fans • Condensers • Plate Fin Exchangers • Longitudinally and Helically Finned Tubing • Bentube Evaporators • Liquid Heaters • Tubular Heat Exchangers • Solution Heaters • Oil and Water Coolers • Tank Heaters • Gas Coolers • Bentube Sections

Griscom-Russell

GENERAL PRECISION EQUIPMENT CORPORATION GPE

THE GRISCOM-RUSSELL COMPANY, MASSILLON, OHIO

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

HEAT EXCHANGE EQUIPMENT FOR THE PETROCHEMICAL INDUSTRY

For more data on advertised products, use Readers' Service Cards, last page.

More REACTIVE

SOLVAY CAUSTIC POTASH

...produces MORE SOLUBLE END PRODUCTS!

Many users select caustic potash, rather than lower cost caustic soda, because it saponifies fats and grease more readily, and—most important—provides extra efficiency.

Since it is more reactive, the products made from it are also generally more reactive—more soluble, more effective. In fact, many powerful cleaners—including some of the popular heavy-duty liquid detergents—are based on products produced from caustic potash.

We invite you to make your own test of SOLVAY Caustic Potash. Available in two grades —Technical and Mercury Cell—dry forms and liquid, in steel drums and tank cars.

Sodium Nitrite • Potassium Carbonate • Caustic Soda • Chlorine
Calcium Chloride • Sodium Bicarbonate • Ammonium Choride
Caustic Potash • Chloroform • Vinyl Chloride • Methylene Chloride
Para-dichlorobenzene • Methyl Chloride • Cleaning Compounds
Hydrogen Peroxide • Aluminum Chloride • Ammonium Bicarbonate
Soda Ash • Carbon Tetrachloride • Mutual Chromium Chemicals
Monochlorobenzene • Ortho-dichlorobenzene • Snowflake® Crystals

SOLVAY dealers and branch offices are located in major centers from coast to coast.

Mail now for test sample!

Allied Chemical

SOLVAY PROCESS DIVISION
61 Broadway, New York 6, N.Y.

Please send me without cost:

Samples of Technical Grade Caustic Potash
☐ Flake ☐ Small Flake ☐ Solid
☐ Walnut ☐ Liquid, 45% strength
☐ Liquid, 49-50% strength

Samples of Mercury Cell Caustic Potash
☐ Flake ☐ Liquid

☐ Caustic Potash fact book

Name_____

Position_____

Company_____

Phone_____

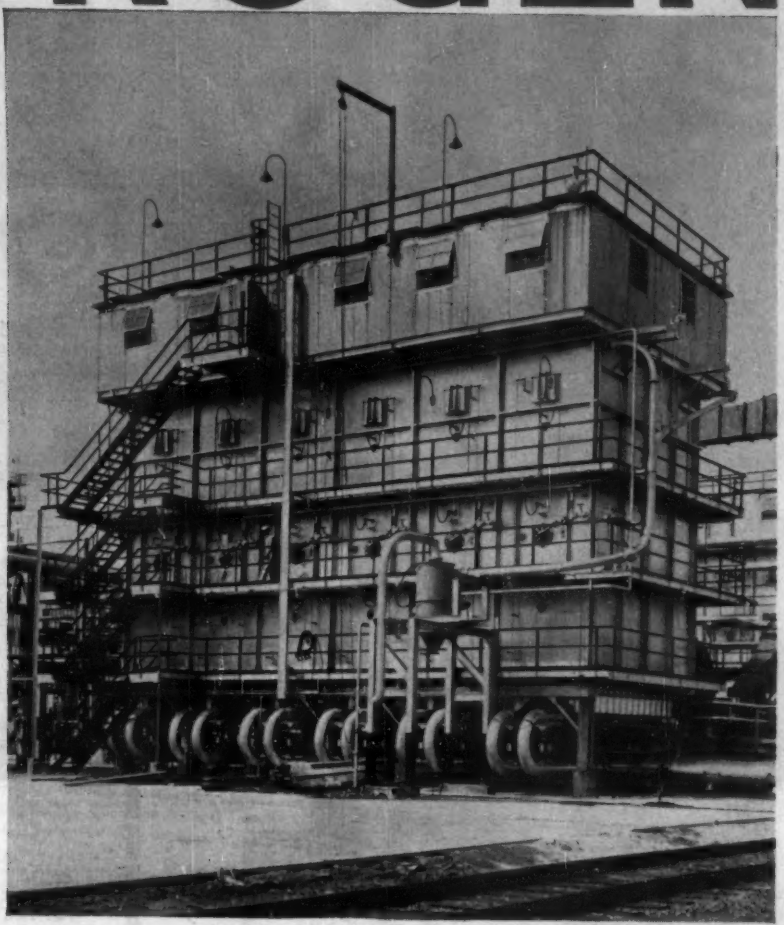
Address_____

City_____ Zone____ State_____ ED-68

For more data on advertised products, use Readers' Service Cards, last page.

HYDROGEN

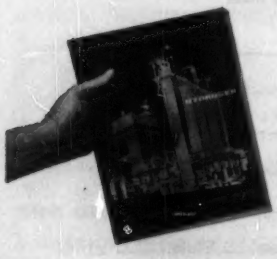
...upgrades products at TIDEWATER'S Delaware Refinery



One of two 15 million cubic feet per day hydrogen reformers at Tidewater's Delaware Refinery. Designed and supplied by Girdler.

The hydrogen reformer shown above is one of two, each rated 15,000,000 cubic feet per day at Tidewater's fabulous Delaware Refinery. These and the feed pretreating units were engineered and supplied by Girdler. The hydrogen produced is used to upgrade intermediates and end products . . . kerosine, diesel fuel, No. 2 fuel oil . . . to attain lower sulfur content, greater stability, better color, better odor.

Here is another example of Girdler's outstanding experience in hydrogen plants. Girdler can engineer and build them for every need . . . any capacity . . . any hydrogen purity. Call Girdler when you start to plan.



New Hydrogen Book

Describes latest, better-known techniques for production, purification and uses of hydrogen. Gives details on hydrogen processes offered by Girdler. Write for your free copy today.

GIRDLER

CONSTRUCTION DIVISION
CHEMETRON CORPORATION

Louisville 1, Kentucky

Sales Offices: New York, N. Y.; San Francisco, Calif.
Engineering Offices: Louisville, Ky.; Orlando, Florida

CHEMETRON

TRADE MARK

For more data on advertised products, use Readers' Service Cards, last page.

These synthetic detergent storage tanks resist corrosion because they're made from Stainless Steel, USS 18-8, Type 304.

To safely store synthetic detergents, we turned to Stainless Steel

"We make synthetic detergent that is mildly corrosive to conventional metal tanks," says Mr. L. R. Henry, Maintenance Engineer at the Atlantic Refining Company "Ultrawet" Plant in Philadelphia. "We have tried other metals and sprayed-on coatings. In our experience, Stainless Steel tanks have given the best protection yet against corrosion and product color deterioration. We've had these Stainless tanks for more than four years without any corrosion problems. We expect them to last about three times as long as conventional tanks."

If corrosion has cut short the service life of your equipment, replace it with Stainless Steel. In the long run, it costs a lot less because Stainless Steel lasts a lot longer. And if you want to be positive of service-tested quality, specify USS Stainless Steel.

USS is a registered trademark

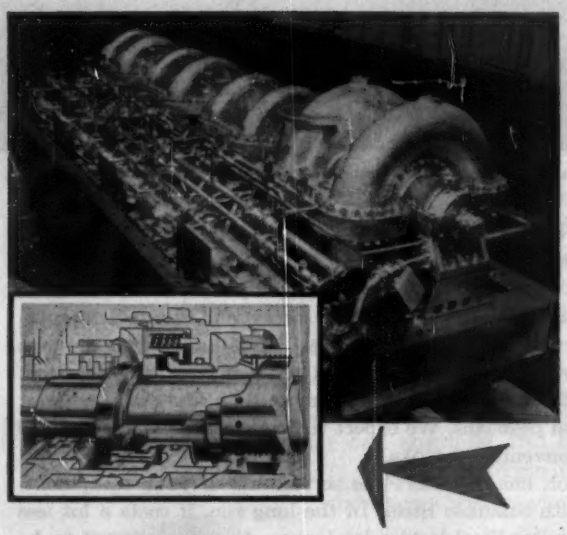
United States Steel Corporation—Pittsburgh
American Steel & Wire—Cleveland
National Tube—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

USS **United States Steel**

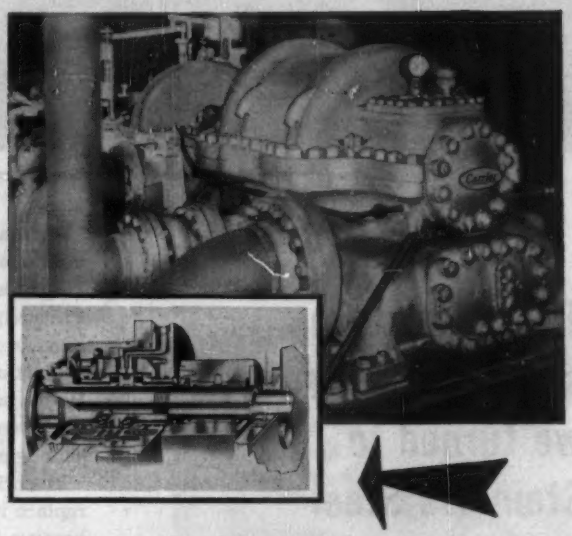
Which is the best way to seal oxygen and hydrocarbon gases?

That depends on the type of gas, its pressure, its toxicity and other factors. No matter what the sealing problem, Carrier Centrifugal Compressors are designed with the right seal for the specific job. For example, an iso-seal is the answer for holding various hydrocarbon gases, especially if the gas must not be contaminated by the sealing fluid or vice versa. At the other extreme, the new Carrier water seal is the correct selection for holding such gases as oxygen where a mixture of oil and the gas cannot be tolerated even in the most minute quantity. For complete information on various compressor seals, call your nearest Carrier office or write Carrier Corporation, Syracuse, New York.

Carrier

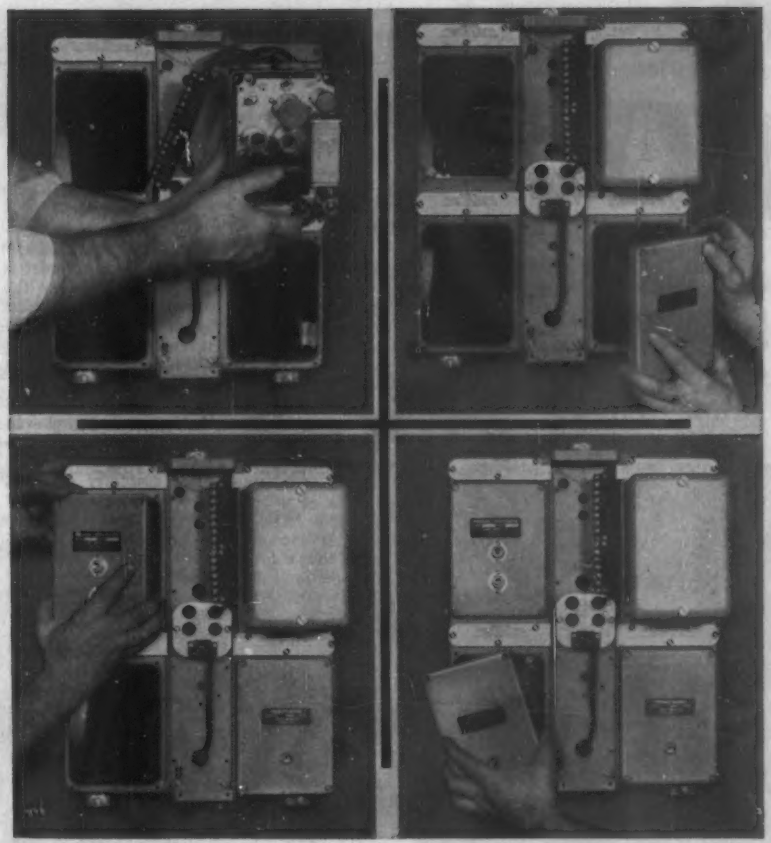


To separate the gas stream from the seal oil system, iso-seals are used in each of these four Carrier Centrifugal Compressors which handle ethylene and mixed hydrocarbon gases in an ethylene plant in Baton Rouge. In seals of this type, seal oil, supplied at slightly higher pressure than suction, is kept from the gas stream by a floating carbon ring. The seal oil pressure is then broken down to atmosphere through one or more narrow floating babbitt steel rings; the number depending on the pressure breakdown. On shut-down, this is a positive seal.



Where there can be no chance of contamination between an oil and a gas such as oxygen, Carrier has developed a new mechanical seal using water as a lubricant to seal the gas from suction pressure to atmosphere. With this new type of Carrier water seal, there is no chance for possible leakage of expensive gas. Through efficiency of design, the number of controls and auxiliaries necessary for dependable operation are held to an absolute minimum. There is no explosion hazard with the new Carrier mechanical water seal.

CUSTOM BUILD your own Bailey Recorder



These four views of the back of a Bailey Recorder show how four plug-in units may be added as needed to meet almost any recorder application.

The freedom and flexibility of "do-it-yourself" instrumentation is yours in the Bailey Recorder. A variety of plug-in units make it possible to record, control, and retransmit any variable that can be converted to a pneumatic or electric signal.

The basic plug-in units are the Bailey a-c and d-c Electronic Receivers and Pneumatic Receivers. Any four of these may be used in one recorder, intermixed in any way, to provide four continuous records on one chart.

For automatic control, other plug-in units are available.

For square root extraction or linear integration, there are two plug-in variations of the Bailey Integrator.

When you want a pneumatic signal that varies according to a pre-set pattern plug in a Bailey Program Controller.

Periodic running time of a condition or process is recorded on the chart when a Bailey Running Time Recorder is used.

These and other plug-in units are described in Product Specification E12-5. Some companies stock Bailey Recorder cases and assorted plug-in units. As instrumentation and control needs arise they build up the kind of recorder-controller required, using the proper plug-in units from stock. Unmatched versatility such as this means lower instrumentation costs.

For the complete story of how easily you can custom build this recorder to your needs, see your Bailey Engineer. G43-1

BAILEY METERS

Instruments and controls for power and process

BAILEY METER COMPANY

1043 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

WHERE MAXIMUM CORROSION PROTECTION IS REQUIRED

PLASITE®

- For Refining Process immersion service
- For Oil Production equipment
- For Heavy Spills and Fumes
- For Severe Atmospheres
- For Tankers and Tank Cars

PROVEN BY LONG FIELD HISTORY IN

High temperature de-ionized tank lining.
Perco treater lining.
High octane gasoline and jet fuel tank lining.
Cooling towers, hot pipings, fans, and structural steel.
Exterior acid sludge tanks.
Sour crude storage tank lining.
Condenser heads.
Roofs of acid separators.
Concrete tanks, floors, sumps, and bases.
PLASITE Cold Set formulated Coatings from combinations of High Resistant Resins are economical to use.

HEAVY SOLIDS with good coverage . . . HEAVY BUILD 5 to 15 mils per coat without sacrificing film quality . . . MINIMUM NUMBER OF COATS due to heavy build feature, saves labor . . . WIDE CHEMICAL RESISTANCE — all PLASITE formulations have excellent overall chemical and specific superior resistance . . . HIGH TEMPERATURE RESISTANCE from 350° to 400°F. on Dry Film basis . . .EXCELLENT BOND — Primers are not required on white blasted steel surface . . . AIR DRYING Field applications without baking or insulation.

OTHER PLASITE PRODUCTS INCLUDE:
CAULKING COMPOUNDS
PRIMERS
BAKING COATINGS
HEAT RESISTANT COATINGS TO 1200°F.

WRITE today for new bulletin No. 258 with complete details, application information, etc. — without obligation.

WISCONSIN protective coating COMPANY GREEN BAY, WIS.

REPRESENTED IN PRINCIPAL INDUSTRIAL AREAS

The Mail Box . . .

Raises Question

To The Editor:

I have looked over the article on "Pipe Supports and Foundations," by S. H. Fistedis [PR, 37 No. 3, March (1958)] and I do not agree with the assumptions therein.

For example, on Page 151 to consider types 3 to type 6 as a pin-type support is contrary to the next statement that the horizontal thrust is applied at the ground elevation for this makes it a fixed support with an equivalent thrust due to the force multiplied by the height acting on, say, a one-foot arm.

This assumption also raises the question of anchor bolts for the posts which should be a part of Table 1 for the tabulated foundations. It would be better to make a small sketch with a table for diameter of bolts, length of imbedment and projection above concrete. The formula for anchor bolt design is too elementary to repeat except that where four anchor bolts are used the full distance between the bolts should be the moment arm and the plate thickness sufficient to resist bending. Deflection is the consideration the young designer neglects. A foundation as described and tabulated is deficient without this (anchor bolt) information.

W. P. Kearney

Fort Lee, N. J.

Author's Answer

The mathematical expressions for the six types of pipe supports (including types 3 to type 6) are based on the assumption that connections between legs of pipe supports and piers are rigid and not pins as W. P. Kearney in his letter to you maintains.

Actually, assuming complete fixity of the joints is not very realistic. Some rotation or yield of the steel at the joint may cut into the 100 percent fixity assumed. It is for this reason, and for the benefit of the designer who prefers to be on the conservative side, that the writer proceeded to develop a formula for this special case. This formula is to satisfy the needs of the ultra-conservative designer who chooses to consider the joints pin-connected. The preference of the writer is indicated by the fact that the solution based on rigid joints is given as the general case, designated by Eq. (3), whereas the solution based on pin joints is presented as a special case and noted as Eq. (3a). Furthermore, this preference becomes more evident in the compilation of Table 1 where only rigid jointed pipe supports are treated.

Eq. (3a) shows quite clearly that in the special case of pin jointed pipe supports the thrust is applied at the top of the pier, referred to as ground elevation. An easy way to assert this point is by observing that Eq. (3a) has dropped the h/2 term appearing in Eq. (3), but it has retained the term a, pertaining to the height of the pedestal.

Mr. Kearney's remarks pertaining to anchor bolt design are very informative and certainly important in the over-all design of pipe supports and their foundations. This paper, however, concentrates its scope in the interaction of pipe support foundations and soil, as affected by dead and wind loads. A steady effort can be noted throughout the paper to avoid discussion of other variables except as they affect the clearly defined area to be investigated. An example of the studious attempt to confine the scope of the paper is the introduction of the parameter H which includes the wind velocity pressure, the shape coefficient of the pipes and pipe supports resisting the wind, the shielding effects, the size and number of pipes, and the spacing of pipe supports. Each of the above variables as well as the structural design requirements of the pipe support as a bent are as important to the over-all design as the anchor bolts.

The writer has found Mr. Kearney's remarks very stimulating and thought provoking. It is certainly commendable for the experienced and busy old practitioners to find the time and prepare discussions of current technical papers.

Stanley H. Fistedis

Argonne National Laboratory
Lemont, Ill.

Author's Book Out

To The Editor:

Thank you for the copies of your Author's Handbook. I have distributed these to our staff and graduate students and will make the others available to our graduating seniors within the next few days.

Your courtesy in supplying these is appreciated.

C. Fred Gurnham, Head
Department of Chemical Engineering
Michigan State University,
East Lansing.

To The Editor:

Thanks for sending me 36 copies of your Author's Handbook.

We have distributed these to our juniors in our course on engineering reports.

I find we could use 10 additional copies to good advantage, and we will be glad to receive them if they are available.

R. A. Ragatz, Chairman
Chemical Engineering Department
University of Wisconsin,
Madison

Editor's Note—Copies of the Third Edition of the PETROLEUM REFINER *Author's Handbook recently were sent to chemical engineering departments of 60 leading universities for distribution to staff and upper classmen. Letters of acknowledgment have been unanimous in expressions of belief that PR has done a good turn thereby.*

Hearty Agreement

To The Editor:

Thanks for your letter and a copy of your own editorial comment ("Another Use of a Foul Tactic," PR May, 1958, p 135) on the remarks of R. M. Blough (chairman of the board, United States Steel Corporation) in reply to the Kefauver statement. We of U. S. Steel heartily agree with your sentiments both with respect to Kefauver-type tactics and to Mr. Blough. I am taking the liberty of forwarding a copy of your letter to the chairman's office.

William T. Garvey, Editor
U. S. Steel News.

Pittsburgh. Pa.

PETROLEUM REFINER welcomes from its readers letters of comment dealing with timely topics pertinent to the industry.

you can meet any lubrication specification if you

BLEND WITH ENJAY PARANOX®

(DETERGENT-INHIBITOR ADDITIVES)

Blended with Paranox, lubricants can be compounded to combine *both* minimum wear and maximum engine cleanliness characteristics. That's why more and more refiners and blenders are relying *exclusively* on Paranox in formulating lubricants for heavy duty equipment and all engines that are subjected to tough operating conditions.

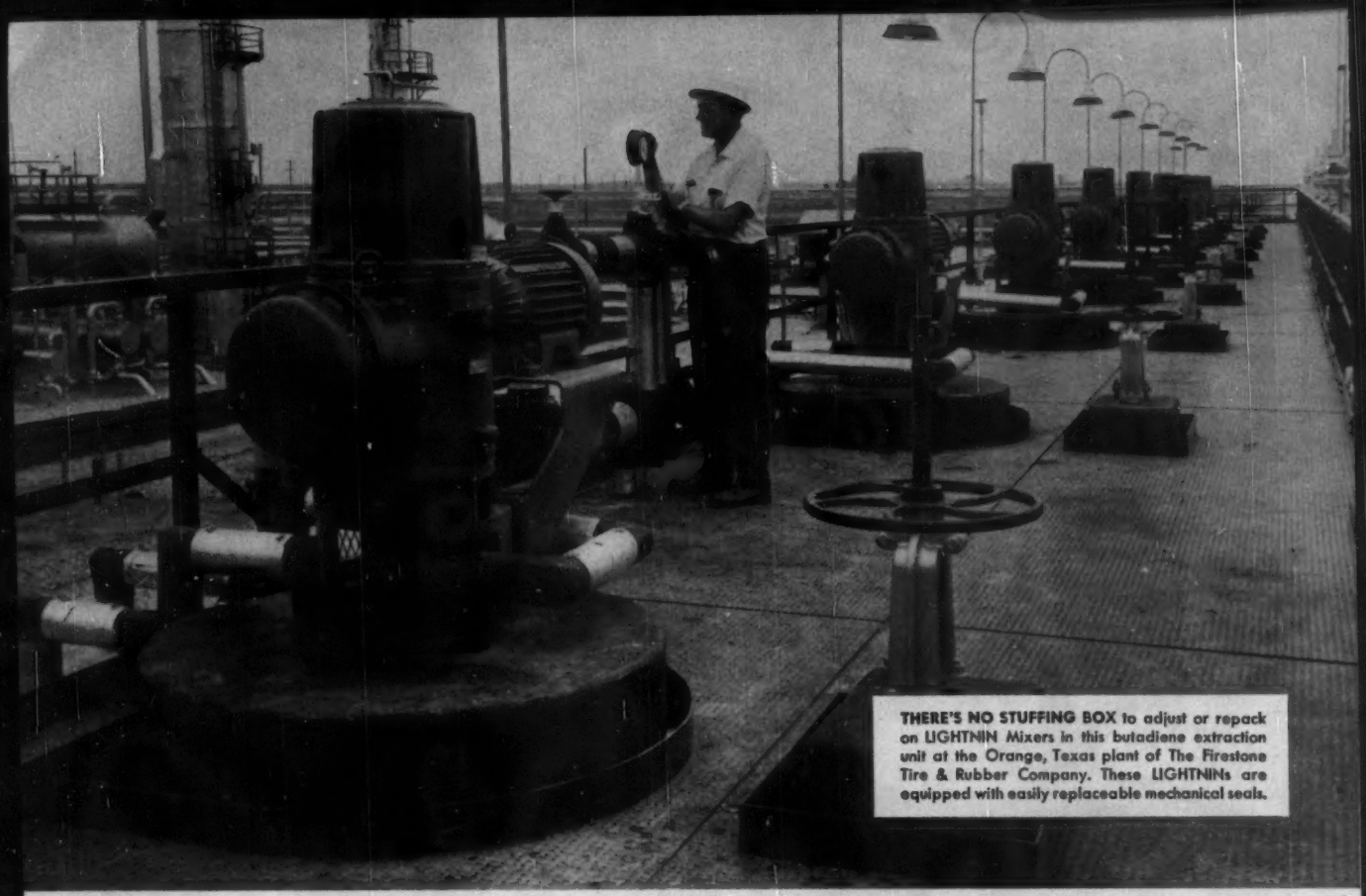
Through years of intensive research and development work with manufacturers and oil companies, Enjay has developed the only *complete line* of high quality additives (Paramins®) that can assure *maximum* performance characteristics. Why not let this experience and know-how work for *you*? Contact the Enjay Company today.

ENJAY

Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 WEST 51st ST., NEW YORK 19, N. Y.

Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa



THERE'S NO STUFFING BOX to adjust or repack on LIGHTNIN Mixers in this butadiene extraction unit at the Orange, Texas plant of The Firestone Tire & Rubber Company. These LIGHTNINs are equipped with easily replaceable mechanical seals.

How to keep a solvent extraction train highballing

A crucial problem facing the engineers who designed this butadiene solvent-extraction train was: how to *keep* it continuous.

In these nine tanks, mechanical mixers were needed to provide intimate contact between the solvent phase and the hydrocarbon phase for quick and complete recovery of butadiene.

But where was a proved mixer design that would keep running for years—without frequent short stoppages for repacking, or costly dismantling in case of a shaft seal failure?

They found the answer in the LIGHTNIN Mixers you see here.

These LIGHTNINs never have to be repacked. Each is equipped with a *mechanical shaft seal that positively prevents leakage*—and runs, not for months, but for *years* without ever needing adjustment.

New shaft seal—in a hurry

Best of all, seal replacement is a fast, simple job.

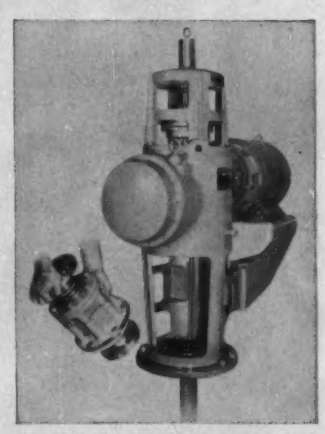
When a seal eventually does wear out, it can be replaced quickly. There's no need to dismantle the mixer or take it off the tank. No need for highly trained personnel, either; any man who can handle a wrench can replace the LIGHTNIN seal.

He merely unbolts two couplings; takes out the seal cartridge as one piece; couples in a new cartridge. Mixer shaft alignment is built-in—need not be checked.

If you're mixing corrosive chemicals under pressure or vacuum, you may save many thousands of maintenance dollars by specifying Series "E" LIGHTNIN Mixers with these quick-change mechanical seals.

You can get LIGHTNINs in hundreds of power-speed combinations, for tanks of any size or shape. Performance is unconditionally guaranteed.

For the full story on increased productivity you get and long-term maintenance savings you make with seal-equipped LIGHTNIN Mixers, call in your LIGHTNIN representative. He's listed in Refinery Catalog. Or write us direct.



CARTRIDGE SEAL runs for years without adjustment . . . and uncouples for rapid replacement.

☐ *Quick! Send us the cost-cutting facts on LIGHTNIN Rotary Mechanical Seals—Bulletin B-111. We'd also like catalog information on these LIGHTNIN Mixers:*

- ☐ Top or bottom entering; turbine, paddle, and propeller types: 1 to 500 HP (B-102)
- ☐ Top entering propeller type: ¼ to 3 HP (B-103)
- ☐ Side entering; 1 to 25 HP (B-104)
- ☐ Portable: ⅛ to 3 HP (B-108)
- ☐ Laboratory and small-batch production types (B-112)
- ☐ Condensed catalog showing all types (B-109)
- ☐ Data sheet for figuring mixer requirements (B-107)

Check, clip, and mail with your name, title, company address to:

MIXING EQUIPMENT CO., Inc., 164-f Mt. Read Blvd., Rochester 11, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Avenue, Toronto 10, Ont.

Lightnin® Mixers™

MIXCO fluid mixing specialists

The Case of an Engineer "Shortage"

W. A. Cunningham and John J. McKetta
The University of Texas, Austin

FOR SEVERAL YEARS representatives of various companies, technical organizations and governmental agencies have been writing articles, making talks and otherwise repeating the old adage "Go West, Young Man, Go West," to youngsters in junior and senior high schools. In this case the "West" was science and engineering. Their efforts have been quite successful and university enrollments in these areas are definitely on the upward path.

The avidity with which the science and engineering graduates were sought indicated that employers had convinced themselves that the shortage was real and that it was at least a semi-permanent condition. Graduating seniors had their pick of as many employment offers as they cared to seek; even the "average" students and the "lower-than-average" students often had a choice of several good offers. Dollar-wise, starting salaries were higher than ever before (so was the price of bread). A few people pointed out that, in purchasing power and in comparisons with craftsmen wages, neither starting pay scales nor salaries of five-to-ten-year engineering employes were indicative of any critical, or even a real, shortage of engineers. Such "prophets of pessimism" were looked upon with kindness—or pity—and ignored. The "shortage" of engineers was self evident; there simply were not enough of them to go around. We needed 10,000 more of them, or was it 30,000? Some thought we needed 50,000 engineers immediately.

The synthetic nature of the "shortage" is painfully evident by the probability that within the short time from one college graduation to the next, *or less than six months,* less than two-thirds of the graduating seniors will be able to step directly from the classroom into industrial jobs. Even advanced degree men are finding that the *demand* for their services has dropped to a whisper. Some companies have cancelled all campus interviews; others have withdrawn offers they actually made earlier, even though in some cases the offers had been accepted by the students.

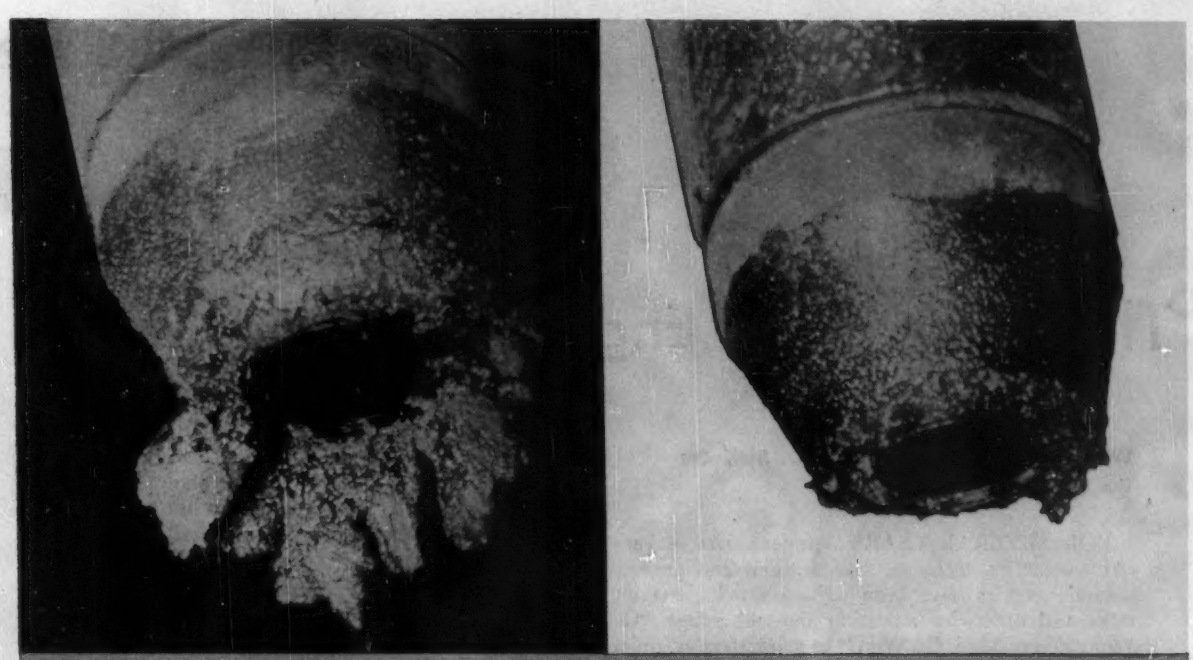
With very few exceptions, a company's current operating profits are not going to be affected significantly by the technical manpower employed or not employed in any one year. Failure to keep a steady flow of capable new engineers into the organization, however, foretells future shortages of qualified and experienced leadership and management personnel.

The very fact that the "shortage" has disappeared in such a short time indicates that it may have been caused by misplaced intercompany competition or by an illogically conceived policy regarding the employment of technical personnel. Neither is pleasant to contemplate.

It should not be too difficult for a progressive company with sane management policies to forecast its needs for technical personnel on a soundly realistic basis. Replacement needs can be estimated with near-statistical accuracy. Growth or expansion needs, while not subject to such accurate forecasting, can be predicted within reasonable limits over such periods of time that local or seasonal variations are usually damped out. On the basis of such projections of needs for technical manpower the adoption of a steady employment policy should be possible. The prestige of the company and of the professions would profit tremendously.

The newly-arisen surplus of engineers, while not alarming as such, calls for reappraisal of the efforts of other agencies and organizations, such as Manufacturing Chemists Association, Engineers Joint Council, American Chemical Society, and many others. Their goals have been achieved far earlier than anticipated; now their efforts might well be expended in persuading the industry to accept and put to work those young men and women, who have been led into engineering by the clarion calls of the very same group now rejecting them. Failure to do this constitutes an open invitation to other vigorous young organizations to step in and question the motives of those of us who have advocated, indeed "preached", the professional individualism of engineers.

Now the above past proponents (they are extremely quiet at the present time), will say that there is still a shortage of *exceptional* graduates. Under the present educational system, all graduates are not going to be exceptional. It does not require the use of a complex computer to recognize that for each "above-average" student, there is one student who is "below-average". And yet, by and large, the



BEFORE FOA-2: This picture shows a typical instance of nozzle fouling caused by sludge.

AFTER ADDING FOA-2: Nozzles stay clean, burner operation is improved; tank contents remain free of sediment.

Du Pont FOA-2 solves sludge problem in refinery heating plant

By WILLIAM deB. BERTOLETTE

Maybe you or your customers have been forced to have fuel oil storage tanks cleaned to get rid of quantities of sludge. With proper treatment this sludge could have been dispersed and burned with the fuel.

For instance, the heating plant of a midwest refinery was using residual fuel containing 40% BS&W, with a very high solids content. Time after time, the storage tank had to be cleaned out to prevent nozzles from clogging and burners from flaming out.

Recently, following a clean-out, Du Pont's Fuel Oil Additive No. 2 (FOA-2) was added to the incoming oil stream in an effort to disperse sludge residue and stabilize the fresh oil supply.

The results were gratifying. After the additive had been used for three weeks, no sludge could be detected in the storage tank.

Effect on the burners

Examination showed the flame pattern was better, there were fewer ash deposits in the furnace, and overall burner operation was improved. (FOA-2 itself leaves no ash at all.)

The dispersing, stabilizing and solubilizing qualities of FOA-2 produced this money-saving improvement. Perhaps this instance suggests a way to improve the distillate fuel oils you sell or use yourself.

We recently published a book about FOA-2, containing all the basic information you need to consider the product. It describes composition and properties, also use concentrations, handling and addition methods, performance testing, and applications. Write us for a copy, or contact your nearest Du Pont Petroleum Chemicals sales office. E. I. DU PONT DE NEMOURS & CO. (INC.), Petroleum Chemicals Division, Wilmington 98, Delaware.

Wm. deB. BERTOLETTE, the author of this article, is technical service supervisor of the fuel oil group at Du Pont's Petroleum Laboratory. For over 20 years he has been closely associated with Du Pont's petroleum additives work.

DU PONT
REG. U.S. PAT. OFF.
Better Things for Better Living
. . . through Chemistry

Tetraethyl Lead
and other
Petroleum Additives

U.S.A. educational system is so set up that even most of the "below-average" men who receive degrees in engineering are in the upper IQ ranges and are fully capable of handling many of the industrial jobs open to new graduates. Events of the past years have proven this.

Who will listen the next time someone cries "wolf"?

Petrochemicals Keep Growing

THE API FIGURES that petroleum chemicals, the wonder children of the oil industry, will need $850 million "to grow on" this year, this amount being the money estimated needed for petrochemical expansion.

And on the same sheet that contained that figure appears this related item typical of what is showing up with some regularity and revealing why the petrochemical industry continues to call for extensive plant development:

Hydrocarbons and carbohydrates make a sweet chemical combination. Paired off by anhydrous hydrogen fluoride, workhorse catalyst of the oil industry, petroleum and sugar have been united to form such diverse products as detergents, petroleum additives, pharmaceuticals, plasticizers, and germicides. This marriage of two of the cheapest and most abundant of chemical raw materials will soon swell the list of petroleum products already at work improving the nation's standard of living.

Mister, That's Public Relations

ONE OF THESE DAYS the oil industry is going to awaken to the sudden realization that there is no magic cure-all that will establish and keep its public relations on a continued effective plane. Then, maybe we can stop waiting for the man with the wondrous formula and start directing some energy to rebuilding oil industry prestige. There are numerous opportunities for doing this . . . but we have to get off dead center and start looking for them. Another piece of propaganda you say? Then just read a success story:

A while back, it became apparent to Columbia Southern Chemical Co. that the eventual expansion of one of its plants would require the land which contained a large Indian mound. The company decided that it should make an effort to preserve whatever archaeological data the mound might hold, as there is far too little information in the world today which sheds any light on the development of mankind. Many promising archaeological sites have been sacrificed in the name of progress, and each time this happens it tears-out a page of pre-history which can never be replaced.

To carry out their plan, the management of Columbia Southern sought the help of the Smithsonian Institution. It was agreed the Institution would send an archaeologist to direct the excavation of the mound, and the company would furnish the necessary labor, equipment, laboratory facilities, and the services of an engineer. Thus the ravages of the bulldozers were avoided and additional information about the prehistoric Adena people, perhaps the earliest permanent residents of the Ohio Valley, was preserved.

We're sure that Columbia Southern performed this civic duty purely as a contribution to the quest for knowledge of prehistoric man, and not as a means for gaining public good will and prestige. Nevertheless, this act prompted Smithsonian Institution's Dr. Setzler to remark that, "By collaborating with the Smithsonian Institution, Columbia Southern has effectively supported a phase of basic research outside its immediate interest and has helped preserve a small segment of the pre-history of North America."

No matter how you look at it. Mister—that's good public relations!

We Must Take The Big Risk

IT WOULD BE DIFFICULT to justify disagreement with Charles M. White's contention that the United States must continue not only to pioneer in the American tradition, but on a scale grander than ever before if she is to fullfill her potential as a nation, according to a leading industrialist. We must take the "Big Risk" whenever a likely opportunity presents itself.

White, chairman of the board of Republic Steel Corporation, points out in the API Quarterly that "there are big risks to be taken in every phase of psychology, sociology and government; in every phase of engineering and the physical sciences; in every area of business and industry."

The industrialist lays stress on the urgent need to develop a "basic research structure that will dwarf anything the world has ever seen."

Other areas in which risk-taking is essential, he states, are this nation's educational system, which must be overhauled and modernized; and the world's undeveloped countries which, through industrialization, can be converted into major markets.

The author cites two examples of bigs risks already taken by American industry. The first of these involves drilling for oil in the Gulf of Mexico. The second is the venture undertaken by mining and steel companies to extract commercial quantities of iron ore from an extremely hard rock called taconite.

White reports that nearly $3 billion already have been invested in these two giant efforts. In the event of war, he says, these operations "could well mean the difference between victory and defeat."

"Our country is strong today," he continues, "because the industries upon which our strength is based dared to pioneer."

"Have we dared enough?" White asks. "To achieve our potential as a nation in the years ahead, we must be willing to take an entirely different kind of Big Risk, and on a scale grander than anything we have ever attempted before except in wartime."

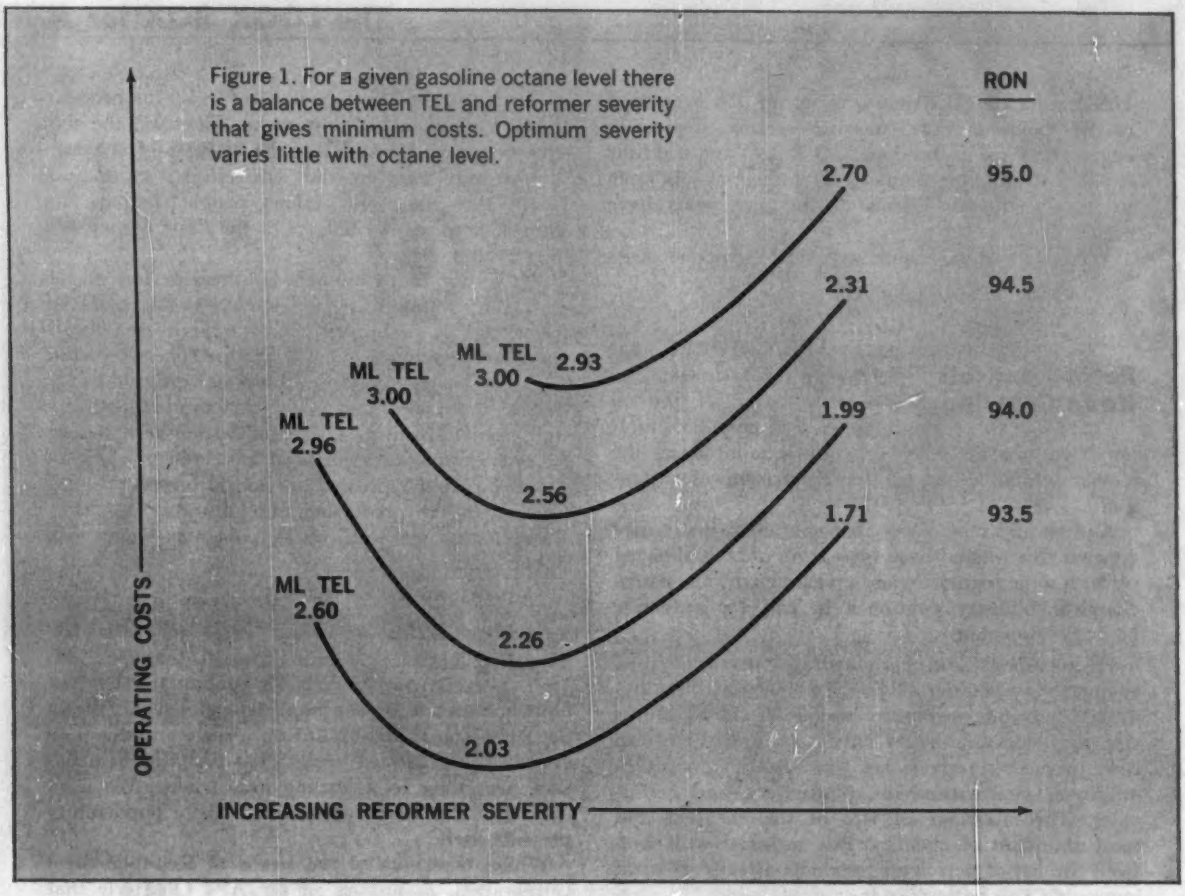


Figure 1. For a given gasoline octane level there is a balance between TEL and reformer severity that gives minimum costs. Optimum severity varies little with octane level.

Ethyl Research Studies Effect of Reduced Charge Rate on Octane-Improvement Costs

ECONOMICS of octane improvement are continually under study in the Detroit Laboratories of Ethyl Corporation. Such studies provide a broad background for solving the specific problems of refiners and also in achieving minimum octane costs.

This work is of particular interest now when the refining industry is operating at lower percentage of capacity. In the light of today's reduced charge rates, the Ethyl Corporation investigations show that refiners can realize substantial savings by re-examining their refining operations carefully.

Using rigorous economic analysis, refiners can define the balance between the cost of tetraethyllead and that of octane-improvement processes for a required gasoline pool. Analysis can also define the optimum allocation of tetraethyllead among the various grades of gasolines to be produced from the pool of components.

Tetraethyllead vs. Catalytic Reforming

In catalytic reforming and tetraethyllead the refiner has two means of octane number control. By increasing reforming severity, he increases octane number at the expense of gasoline yield. With tetraethyllead, he increases octane number at the expense of higher concentrations.

There is a definite balance between reforming severity and tetraethyllead concentration that results in minimum cost for any set of conditions.

Figure 1 is a typical plot of cost versus reformer severity for different Research octane number levels. Tetraethyllead concentrations are indicated on the cost curves. They decrease as severity is increased, and the optimum tetraethyllead is defined by the point of minimum cost. As octane number is increased, optimum tetraethyllead rapidly approaches maximum concentration. At the same time, reformer severity increases very little. Figure 1 is representative of many refining situations today.

Octanes Influenced by Crude Charge Rate

The refining industry is operating at a significantly lower per cent of capacity today than it was a year ago. This affects pool octane quality. At reduced crude runs, catalytically cracked gasoline makes up a bigger part of the gasoline pool

For more data on advertised products, use Readers' Service Cards, last page.

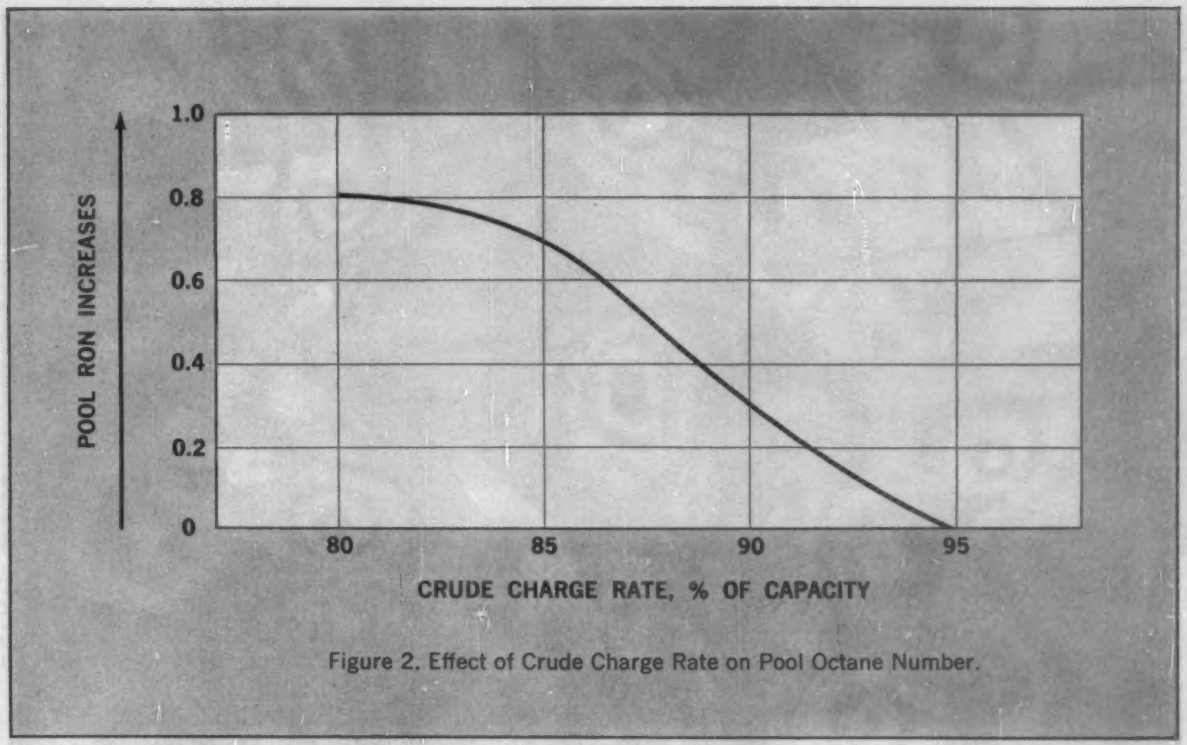


Figure 2. Effect of Crude Charge Rate on Pool Octane Number.

and pool octane quality may be higher.

Also, catalytic reforming capacity, as a function of crude run, is higher which enables a larger percentage of naphtha to be upgraded. Refiners must consider the effects that this stiuation has on their present and planned operations.

Figure 2 illustrates the effect that crude charge rate may have on the RON quality of a gasoline pool. A decrease in the percentage of crude running capacity in operation raises the pool octane number. This effect can be as much as 0.5 to 1.0 octane numbers.

Operations Today are Less Severe than Last Year

At present, relative to a year ago, reforming severity and tetraethyllead in the average refinery have undoubtedly shifted as a result of several factors. The higher ratio of cat cracking capacity and reforming capacity to crude runs enables refiners to produce a given octane quality with less severe operations.

Therefore, in order to make the best use of tetraethyllead and reforming for octane improvement, the balance between reforming and tetraethyllead must be frequently reviewed and studied.

Directionally, at lower percentages of capacity operated, reformer severity should be somewhat less (higher reformate yield) in order to get the most efficient use out of tetraethyllead. The curves shown in Figure 1 would shift to the left under these conditions.

Ethyl Research is constantly testing all of the variables which affect the use of tetraethyllead and the cost of octane-improvements. Results obtained are passed along to the Oil Industry to help individual oil companies achieve optimum production economy.

How Ethyl Research is helping you

Our Refinery Technology staff, backed up by the extensive facilities of the Detroit Laboratories, will be glad to share their experience with your economics people when you conduct an analysis of your octane-improvement costs.

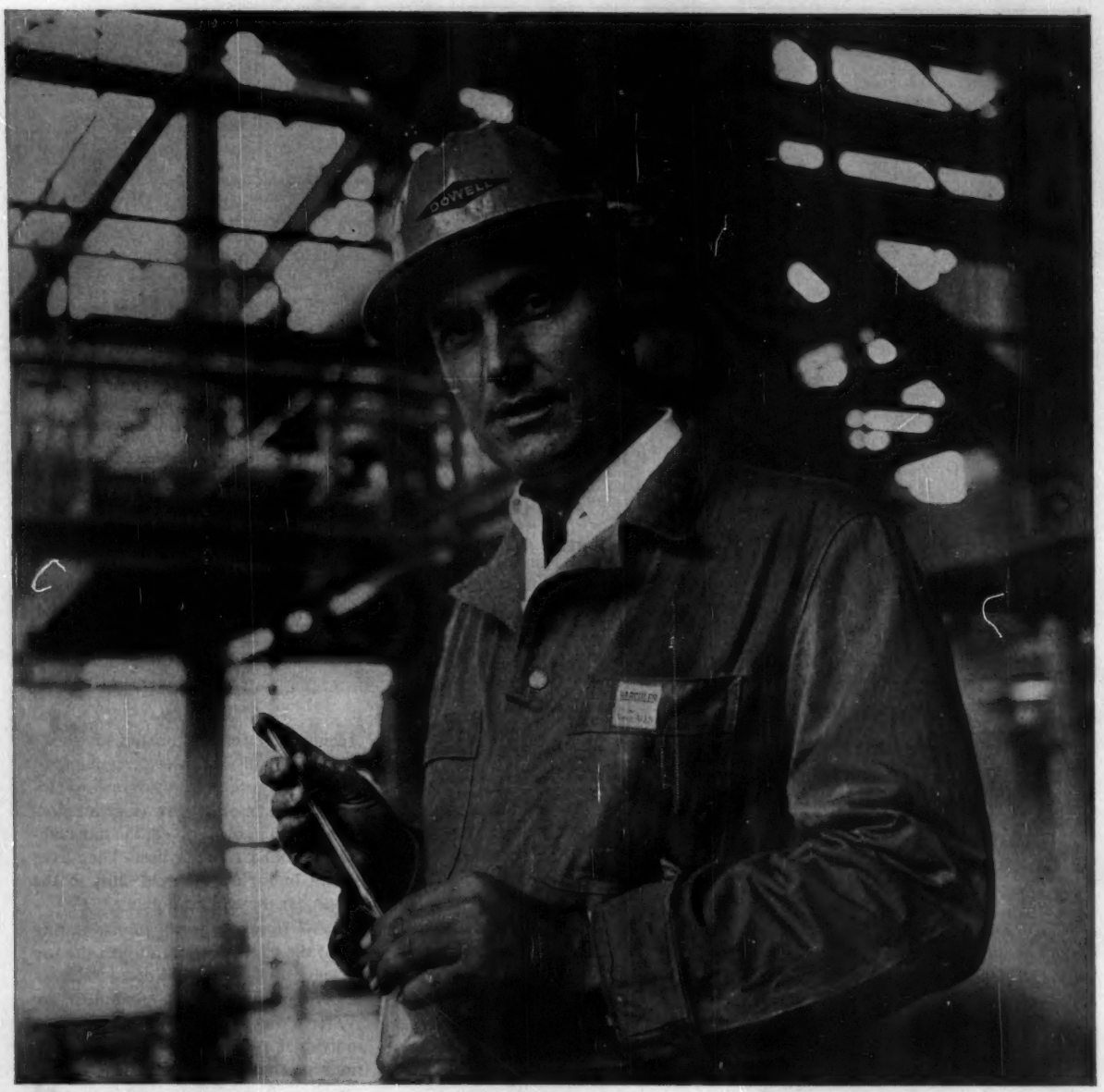
For further information, call your Ethyl Representative. He will be glad to arrange an appointment for you with one of our Refinery Technologists.

ETHYL CORPORATION
New York 17, N. Y.

ETHYL
ANTIKNOCK COMPOUND
ETHYL CORPORATION

RESEARCH LABORATORIES:
1600 W. Eight Mile Road, Ferndale 20, Mich.
2600 Cajon Road, San Bernardino, Calif.

For more data on advertised products, use Readers' Service Cards, last page.



HE CAN "MEASURE" MORE PROFIT FOR YOU. This Dowell service engineer can measure the amount of scale he removes from a line, using the Dowell method of chemical cleaning. *This removed scale and sludge can also be measured in increased profit dollars for your company.*

Example: Scale build-up in the main water supply line of a major Midwestern plant had reduced the "C" factor from 105 to 72. This situation became apparent just at the start of the peak season for the company. Management had a choice between laying an auxiliary line or trying to clean their present one. They decided to clean the line—but not the old-fashioned mechanical way. Time would not permit. Dowell was called in to do the job—chemically.

Dowell Service was fast—the job was done in three days. Dowell Service was effective—the "C" factor was increased to 92. Dowell Service was profitable for the customer—$71,000 was saved and the company's annual profit was protected.

With Dowell Service you receive the benefits of more than fifteen years experience in chemical cleaning—plus a full line of equipment, chemicals, and trained personnel. You pay one charge, get an efficient job, handled by experienced people.

Your maintenance and operating engineers probably know about Dowell Service. Ask them for the facts. Decide for yourself about the additional profit possibilities to your company with Dowell Service working for you. DOWELL—A SERVICE DIVISION OF THE DOW CHEMICAL COMPANY. Headquarters and research center, Tulsa, Oklahoma, with 165 offices and stations to serve you.

Chemical cleaning service for industry DOWELL

THEY HELPED PLAN THIS SPECIAL REPORT: To present you, our reader, with the latest information available on costs, we asked the advice of these industry experts on what our authors should cover. Attending the conference were, left to right: Dr. S. C. Schuman, Hydrocarbon Research Inc.; Frank Rubin, Downington Iron Works; Bernard H. Rosen, Cities Service Research and Development Company; Sam Dickens, The Texas Company; Dr. E. P. Bartkus, DuPont; R. J. Musser, Carbide Chemicals Company, and L. F. Mekler, consultant.*

Special Report on COSTS

IT HAS ALWAYS been true that in an efficient industry it is important to save money; but in an economy such as prevails today, it is downright imperative that we do so. Direct manufacturing and raw materials costs always seem to get plenty of attention. Too often unnoticed, however, are the indirect, intangible costs. And many times these will make or break a project. So this Special Report is devoted to these intangible factors which frequently are overlooked.

Of all economic activity, capital cost estimating probably gets the most attention, "What Affects Estimate Accuracy?" (Page 128) discusses, along wih estimating methods, the importance of project definiton, job conditions, estimator skill, the use of cost records in making good estimates etc.

You can waste money and not get good equipment by following old, outdated specifications, "How to Save Money on Exchangers" (Page 135) takes a fresh, realistic, engineering approach and shows how you can get a better exchanger at a lower cost and with a prospect of cheaper operation.

A rough estimate might do the job if the uncertainties in the data were properly evaluated. "How to Improve Estimate Accuracy" (Page 142) points out the limitations of estimating data and how proper knowledge of these uncertainties can save estimating time and money. "Process Evaluation from Lab to Plant" (Page 146) gives a step-by-step example of the application of process evaluation from research through engineering to the completed plant. This can prevent false starts so expensive in today's economy. Rapid decisions as to the effect of changing variables on any project are a must. "How a Computer Aids Economic Studies" (Page 151) explains computer applications for studying the effect of changing variables on the over-all estimate. In fact, this article is so detailed that all the mystery of using computers is completely removed. If you are anticipating computer applications, this is *must* reading.

After all these tools have been applied, what are the chances for success of any new project? "These Factors Affect Project Success" (Page 164) illustrates many of the important factors that can mean sink or swim for a new venture. Success is never certain, but the risk can be reduced by checking these factors.

*The attendance by executives, engineers, superintendents or other employes of oil companies at these editorial conferences does not constitute an endorsement of the REFINER or any other publication. The fact that these industry leaders are allowed to attend the planning conferences shows the interest which companies have in the planning of sound editorial content for the industry.

What Affects Estimate Accuracy?

Here are five of the most important factors in estimate accuracy: Project definition, forecasting job conditions, estimating method used, cost records, and estimator skill.

John W. Hackney, Diamond Alkali Company, Cleveland

AN IMPORTANT phase of developing a process project is estimating its capital cost. This is an attempt to foretell, using data which are often limited and obscure, just how much money will be required to carry out a project. For example, how many dollars will a plant cost which will convert a given feed stock into a required group of products at a specified daily production rate.

Some of the high points of this type of estimating will be covered. Not only is the field very broad, but the techniques of capital cost estimating are expanding. A variety of methods and procedures are being developed, suitable to various kinds of projects and for use with project information of varying degrees of completeness.

This estimating system is a combination of methods suggested in recent estimating literature, plus a few innovations. With these innovations, it is an approach to an integrated, complete capital cost estimating procedure.

Why Estimate? The need for good cost estimating is obvious to a lump-sum construction contractor—a low estimate usually means he will lose money. A low estimate may cause cost cutting and shoddy work. This may save one job, or even two, but will ruin his reputation and bankrupt him.

High estimates are just as bad to the lump-sum contractor. He will get few jobs, his organization drifts away, and every bid he loses involves out-of-pocket loss of his bidding cost.

UNCERTAINTY RATING SUMMARY

Project No. VC-214
Titled Reforming Unit

Item	Maximum Uncertainty Rating By Date	Group Sub-Total, This Project	Notes
A. General Project Basis			
Products & By-products	100	0	Specified in Study ZF-60-1
Feed Stock	100	0	Same as present
Process Background	200	5	Some innovations
Subtotal, General Project Basis	(400)	5	
B. Project Basis Multiplier (One plus 1% of Subtotal, General Project Basis)	5.00		
C. Process Design Status			
Flow Balances (Material, Heat, Power)	70	0	Complete
Major Equipment, Type & Size	80	0	"
Materials of Construction	30	0	"
Review with Research, Development and Operations	70	0	"
Subtotal, Process Design Status	(250)	0	"
D. Site Information			
Surveys, Including Obstructions and Sub-soil	45	25	
Re-usable Equipment	25	-	
Re-usable Supports, Piping & Elec.	25	-	
Buildings Available	30	-	
Utilities Available	25	0	
Yard Improvements Available	25	0	
Climatological Information	30	0	
Local Ordinances & Regulations	30	0	
Review with Operations	25	15	
Subtotal, Site Information	(240)	[illegible]	Preliminary check only
E. Engineering Design Status			
Layouts	35	35	
Line Diagrams, Incl. Utilities	50	50	
Auxiliary Equipment, Type & Size	45	45	
Buildings, Type and Size	35	35	
Yard Improvements, Types and Sizing	25	25	
Hazard Control	25	10	
Coating Specifications	10	10	
Review with Operations	70	60	
Subtotal, Engineering Design Status	(295)	[illegible]	Not begun
F. Detailed Design Status			
Drawings & Bills of Material	45	45	
Drawing Checks	25	25	
Subtotal, Detailed Design	(70)	[illegible]	Not begun
G. Field Performance Status	(50)	[illegible]	" "
H. Subtotal, Sections C thru G	(905)	[illegible]	
I. Uncertainty Rating (Subtotal H Times Multiplier B)	6.525	[illegible]	
J. Recommended Contingency			
Unlisted Items (% of base Cost)		10	
Restricted Reserve (% of Base Cost Plus U.I.)		17	

FIGURE 1—Uncertainty Rating Summary form. The maximum uncertainty rating is given for each item with the uncertainty rating for the illustrated project written in.

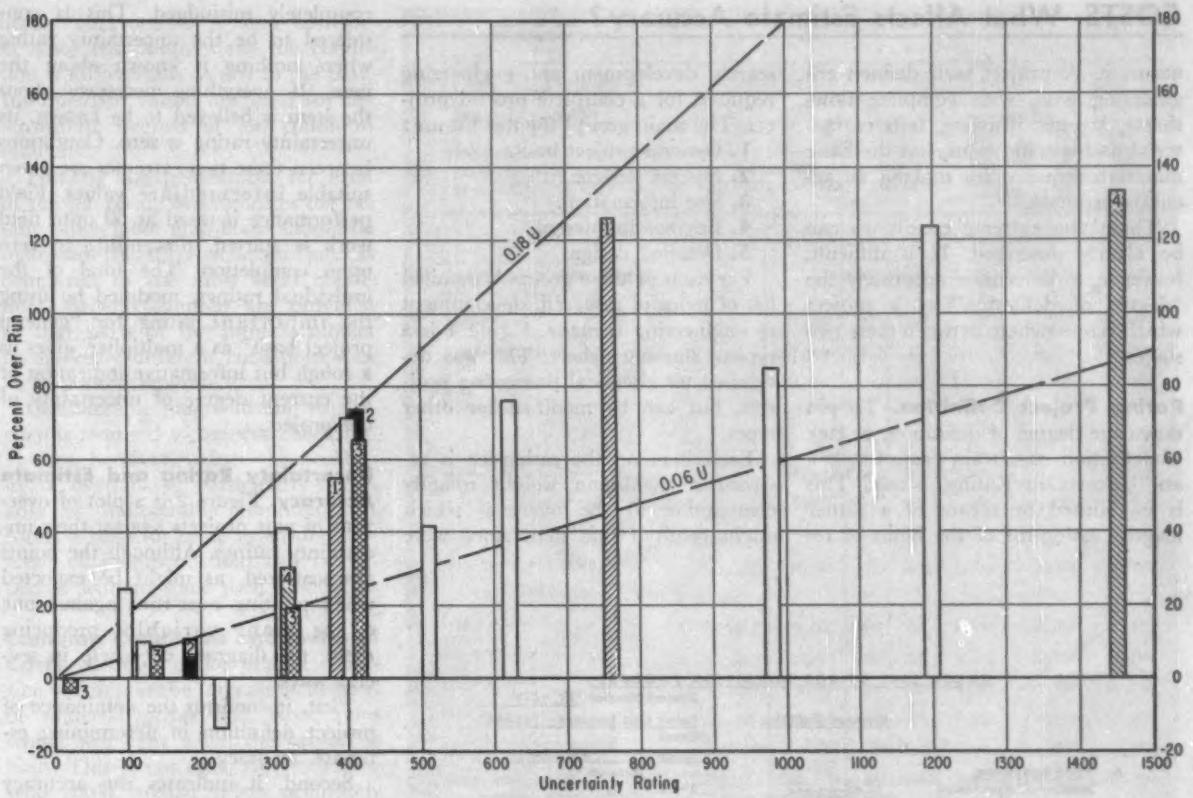


FIGURE 2—Percentage over-run plotted against uncertainty rating at time of estimate. This confirms the importance of project definition and indicates the spread of accuracy to be expected at various degrees of uncertainty.

Low estimates are not quite so serious for the cost-plus-fee contractor, but they involve loss of owner-confidence, long conferences on why costs are running high and perhaps the loss of future jobs. High estimates may give the job to another contractor, and in any case leave the impression that the contractor doesn't know his business and will not be careful with the owners money.

For the owner, low estimates are very disturbing and damaging. Available funds may be insufficient and cause the work to be abandoned. Or additional and perhaps more expensive capital must be found. Even if money is available, there is "loss of face" and a taint of poor management when a job over-runs its estimate.

The project will produce less return than expected, and it could be that some other, more profitable project should have been built instead.

A low estimate usually results in inadequate planning with consequent loss of efficiency. Neither the owner nor the contractor realizes the complete scope of the project. This incorrect idea of the money and time required for the project, causes unrealistic sales commitments. The consequent confusion, overtime and makeshifts for early operation further increase the cost of the project.

High estimates, from the owner's point of view, may mean that the project will be discarded, even though it actually would have made money. Really worthwhile projects are scarce and a company hates to pass up a good one. To stay in business, new, profitable projects must continually be introduced to prevent obsolescence.

Loss of project cost control is common on either high or low estimates. High estimates tend to "gold-plating" —to adding desirable, but not essential features as surplus funds appear. A very low estimate has the same effect. As soon as it becomes obvious that the cost estimate is unrealistic, the estimate ceases to be a control and the "gold-platers" go merrily on their way, armed with the iron-clad excuse that the estimate was obviously too low.

What Affects Estimate Accuracy? Its agreed that estimates should be accurate. Now, let's isolate and analyze some of the factors affecting accuracy, with the object of improving estimates and determining the accuracy which can be expected from a given set of circumstances.

The following major factors affect estimate accuracy:

1. Degree of project definition.
2. Accuracy of forecasting job conditions.
3. Estimating method used.
4. Adaptability and accuracy of available cost records.
5. Skill of the estimator.

Of the above factors, "degree of project definition" is dominant. With only a vague idea of what the completed project will be, it is unreasonable to expect the estimate to be

accurate. A project well defined engineering wise, with complete flowsheets, layouts, drawing, bills of material and specifications, has the basic materials required for making an accurate estimate.

These two extreme conditions can be clearly described. It is difficult, however, to determine accurately the "degree of definition" of a project which is somewhere between these two stages.

Rating Project Definition. To pin down the degree of definition, or lack of definition, at certain project stages, an "Uncertainty Rating" is used. This is established by means of a rather lengthy rating-list of the items of research, development and engineering required for a complete process project. The main groups for this list are:

1. General project basis.
2. Process design.
3. Site information.
4. Engineering design.
5. Detailed design.

For each of these groups a detailed list of items of research, development or engineering is made. Figure 1 is a typical summary sheet. This was developed for chemical processing projects, but can be modified for other types.

Each item on the rating-list is assigned a maximum weight roughly comparable to the over-run which might result if that item alone were completely misjudged. This is considered to be the uncertainty rating where nothing is known about the item. If everything necessary about the item is believed to be known, its uncertainty rating is zero. Conditions between these two extremes are given suitable intermediate values. Field performance is rated at 50 until field work is started, descending to zero upon completion. The total of the individual ratings, modified by using the important rating for "general project basis" as a multiplier, gives us a rough but informative indication of the current degree of uncertainty of the project.

Uncertainty Rating and Estimate Accuracy. Figure 2 is a plot of over-runs of past projects against their uncertainty ratings. Although the points are scattered, as might be expected when plotting over-runs against one of the many variables producing them, the diagram does help in several ways.

First, it confirms the dominance of project definition in determining estimate accuracy.

Second, it indicates the accuracy spread band which may be expected at various degrees of project uncertainty.

Third, it can aid in establishing contingency allowances, which are discussed later.

Data for this diagram was obtained from several chemical processing companies. For uniformity, all contingency allowances were removed from the estimates before computing over-runs. Therefore there was no actual over-run of the "estimate including contingencies" for several of the projects illustrated. Estimates for projects to the right of the chart are definitely of the "quickie" variety, and only those with a rating of fifty or less were completely engineered at the time of the estimate. Numbered bars indicate successive estimates of a single project.

Job Conditions and Labor Costs. The second factor affecting estimate accuracy is the reliability of forecasting conditions during construction. The conditions at the job site, (see "Checklist of Job Condition Factors," Figure 3) are important because they affect labor cost. A range is given for each item. The higher percentage is the increase in labor cost of the project if this particular job condition is

CHECK LIST OF JOB CONDITION FACTORS

Project Number YC-214

		Expected Condition	Labor Cost Increase - Percent: Usual Range	This Job: Area-10		
A.	Field Supervision					
	Number of Supervisors	Adequate	0 - 14	0		
	Competence	Excellent	0 - 14	0		
	Organization & Leadership	"	0 - 14	0		
B.	Field Labor					
	Competence	Fair	0 - 35	4		
	Willingness	"	0 - 35	4		
C.	Type of Contract	Cost plus fixed fee	0 - 10	5		
D.	Construction Equipment and Tools					
	Major Equipment	Adequate	0 - 40	0		
	Tools & Minor Equipment	"	0 - 35	0		
	Maintenance	"	0 - 20	0		
E.	Construction Facilities and Service					
	Storerooms and Yards	Adequate	0 - 5	0		
	Shops and Offices	"	0 - 5	0		
	Personnel Facilities	"	0 - 5	0		
	Temporary Utilities	"	0 - 5	0		
F.	Physical Working Condition					
	Weather	Indoor	0 - 25	0		
	Mud, dust, altitude	None	0 - 15	0		
	Fumes, heat, and hazards	Near chemical equipment	0 - 40	5		
G.	Access to Work					
	Roads	Good	0 - 10	0		
	Height	Ground level	0 - 40	0		
	Other	—	?	—		
H.	Construction Program					
	Build-up rate	Normal	0 - 10	0		
	Area Loading	"	0 - 10	0		
	Interruptions	Occasional	0 - 15	2		
I.	Material Coordination	Good	0 - 12	0		
J.	Engineering Coordination	"	0 - 8	0		
K.	Engineering Quality	"	0 - 12	0		
L.	Other Conditions					
	Smoking restricted		?	2		
M.	Standard Condition Factor			100	100	100
		TOTAL JOB CONDITION FACTOR		122%	%	%

By A. W. Right Date 6/11/57

FIGURE 3—Check list of job condition factors. The usual expected range is given with the range for the illustrated project written in.

highly unfavorable. A zero increase in labor cost assumes the job condition is as favorable as any in the past. Intermediate values are used for intermediate degrees of job condition difficulty.

Totaling the percentages for each of the job conditions indicates the extent which labor man-hours should be increased for this particular job, as compared to the most ideal conditions. Several columns are provided so that parts of the project, subject to markedly different conditions, can be appraised separately.

Considerable judgment and experience is required to use this check list. It does, however, reduce the possibility of overlooking particularly favorable or unfavorable conditions. It forms a basis for more rapid development of judgment than can be expected without some such guide.

Economic Conditions and Material Costs. Another major project condition which must be forecast is the level of material prices and labor rates which will exist when the project is built. This is not easy. Any estimator who could predict prices accurately and consistently would be much in demand. In spite of the difficulty, however, a forecast must be attempted. After all, the assumption of no change is itself a forecast, and more often wrong than right.

Cost indexes give regular information on price changes. The Marshall and Stevens Index for equipment is often useful.

Cost indexes are of particular value in updating previous costs. The corrections may be substantial. In general, construction prices have doubled in fourteen years between 1933 and 1947 and doubled again in the ten years from 1947 to 1957.

When time is available, quotations should be obtained for items having a major influence on the estimate. They are much more accurate than any indexed price.

Potential increases in the average wage scale should also be considered. Sometimes automatic or generally expected wage increases will take place during the life of the project. Conversation with construction men may be helpful in establishing current thinking about "how much the boys are going to get." At the very least, the current rates should be assumed to change in proportion to the change forecast in the construction cost index.

EQUIPMENT RATIO ESTIMATE

PRODUCTS: HIGH OCTANE COMPONENTS	LOCATION: TULSA			DATE: 3-15-57	STUDY NO: EF-00-1		
PROCESS: CATALYTIC REFORMING				EST. NUMBER THIS APPROP: 3			
CAPACITY: 2,500 bpd				ESTIMATE TYPE: IV			
ESTIMATE BASIS: MAJOR EQUIPMENT PRICES FROM QUOTES. RATIOS FROM JOB NUMBER EF-42-6751. EQUIPMENT LIST AND FLOW SHEET FROM REPORT PSN #430.				UNCERTAINTY RATING: 450 UNLISTED ITEMS: 13.5 % ENR COST INDEX: 740 JOB CONDITION FACTOR: 1.28 740/740 x 1.28 / 1.30 = .69 EFF. PAY RATE: $3.50			
DESCRIPTION & QUANTITY	MATERIAL	M.H./$ STD.	M.H./$ JOB	LABOR MAN-HRS	LABOR DOLLARS	TOTAL	
SITE CLEARING, RECONDITIONING, AND LAND REMOVE BRICK WAREHOUSE	—	Field	Check	3,200	12,200	12,200	
MAJOR PROCESS EQUIP., INCL. UNLISTED ITEMS VESSELS	53,000	.010	.007	370	1,400	54,400	
HEAT EXCHANGERS	115,000	.016	.011	1,270	4,800	119,800	
COMPRESSORS	51,000	.040	.028	1,430	5,400	56,400	
NEW VALUE OF RE-USED EQUIP. Heater	49,000	Field	Check	1,200	4,600	4,600	
UNLISTED ITEMS FOR RE-USED EQUIP., 13.5%	6,600	—	—	160	600	7,200	
TOTAL MAJOR PROCESS EQUIP. = 274,600	****	**	**	***	****	****	
AUXILIARY EQUIPMENT, INCL. UNLISTED ITEMS = .118	32,400	.050	.035	1,140	4,300	36,700	
TOTAL PROCESS EQUIPMENT = 307,000	****	**	**	***	****	****	
INSTALLATION MATERIAL = .027	29,800	.69	.48	14,300	54,400	84,200	
PIPING MATERIAL = .161	49,400	.26	.18	8,900	33,800	83,200	
WIRING MATERIAL = .018	5,500	.45	.31	1,710	6,500	12,000	
BUILDING MATERIAL = .022	6,800	.60	.41	2,790	10,600	17,400	
DISTRIBUTION & YARD MATERIAL = —	Battery Limits Unit				—	—	
COPIES TO: Comm. Dev. / Research Group / Tulsa Plant	SUB TOTAL, NEW MATERIAL	$ 349,500					
	SUB TOTAL, INCL. RE-USED MATERIAL	(398,500)	.321	.083	36,470	138,600	$ 488,100
	DESIGN EXPENSE = $9.00 $/M.H.	323,000	.041	.041	(13,200)	119,000	$ 119,000
	FIELD EXPENSE, 12% OF SUB TOTAL	26,500	—	—	8,530	32,400	$ 58,900
	TOTAL ESTIMATED COST	$ 376,000	***	***	FIELD 45,000	290,000	$ 666,000
	RESTRICTED RESERVE 36% of $666,000						$ 234,000
	TOTAL ESTIMATED COST PLUS RESTRICTED RESERVE						$ 900,000
CONST. FILE	ESTIMATOR: D. R. Smith	DATA CHECK: J. J. L.	ADMIN CHECK: J. B. S.	APPROVED: A. W. Right			EST. TIME TO C: 8 hr.

FIGURE 4—Tabulation form for use in equipment-ratio estimating.

Estimating Methods. The third item affecting estimate accuracy is the estimating method used. Originally the only accepted method of estimating was a detailed take-off of all the items of material and labor required, with each item priced in accordance with past experience. In today's fast-moving, highly-technical expansion of the oil processing industry this is not adequate. Reasonably reliable estimates are needed very early in the development of a project, before the information required for a complete take-off is available. This is to insure that appropriations for project research, development and engineering will be spent well. Additional, increasingly accurate estimates are needed as the project advances to be sure it is still on the right track. For each of these estimates additional and more accurate data will be availbale.

The estimator, therefore, needs a correlated array of estimating methods, one of which will best fit the project at any stage when he is asked to make an estimate. Several such arrays have been proposed. The following is in current use by the author:

1. Detailed Estimates
2. Preliminary-Bill Estimates
3. Layout Estimates
4. Equipment-Ratio Estimates
5. Capacity-Cost Estimates

Detailed estimates are used only for projects which have been completely engineered and for which the substantial cost of such an estimate is justified. Several books have been published as guides to this type of estimating.

Preliminary-Bill Estimates are used

when most of the material has been established and billed, but drawings are incomplete and time is pressing. Materials on the bills is priced from current price lists or quotations. Labor is estimated by means of labor-material ratios established on past jobs. Corrections are made for the expected job conditions and for changes in material costs as indicated by construction indexes. Expected average effective labor rates, including payroll-based overhead and an allowance for equipment rental are applied to the man-hours to determine the total labor cost. Construction overhead expense is estimated from a percentage curve based on past projects. Cost of engineering for this type of estimate is mostly a matter of record and the cost of its completion can be easily estimated.

Layout Estimates are used when complete flow-sheets, plant layouts and equipment lists are available, but no detailed installation drawings have been made. Prices for process equipment are obtained from vendors or from published information, corrected by cost indexes. Materials required to install the equipment are estimated on the basis of ratios from past projects of a similar type. The cost of material for buildings can be approximated on a square-foot basis, since their size, height and general type is known. The cost of material for railroads, roads, sewers, power feeders etc., is similarly estimated on a unit price basis with the aid of the general plant layout. Labor and construction overhead expense are estimated by ratios and percentages as outlined for the Preliminary-Bill method. The cost of detailed engineering is estimated from a percentage curve summarizing past experience with similar projects.

Equipment-Ratio Estimates require no general plant layout. It is not even absolutely necessary that a geographical location be established for the plant. A flow sheet and a list of major process equipment are required, with sizes, types and materials specified for the equipment. Buildings, distribution systems and general plant facilities are estimated by ratio from experience on past projects. Otherwise the procedure is the same as for a Layout Estimate. A standardized form for this type of estimate is shown in Figure 4.

Capacity-Cost Estimates are based on the fact that log plots of costs of similar plants versus capacities give straight lines indicating an exponential relationship between capacity and cost. This relationship is only a generality, however. The particular conditions of a project can greatly affect its cost, and the capacity-cost relationship should not be used for estimating complete projects from other project records if it can be avoided.

For example—assume records are available for a 25,000 bpd plant which cost $900,000. For the cost of a 5000 bpd plant, use the following formula:

$$\frac{\text{Cost of Plant A}}{\text{Cost of Plant B}} = \left(\frac{\text{Capacity of Plant A}}{\text{Capacity of Plant B}}\right)^{x}$$

or,

$$\frac{\text{Cost of Plant A}}{\$900{,}000} = \left(\frac{5000\text{ bpd}}{2500\text{ bpd}}\right)^{0.7} = 2^{0.7}$$

$$\text{Cost of Plant A} = \$900{,}000 \times 1.63 = \$1{,}500{,}000$$

The capacity-cost exponent in the above example was assumed to be 0.7. This ratio is often encountered, but it may be substantially higher or lower. If capacity is increased by adding units of the same size, the exponent may be close to 1.0.

Again it should be emphasized that this relationship applies only to very similar projects—and such projects are the exception rather than the rule.

Cost Records. Because of their powerful influence on estimate accuracy, cost records are the heart of an estimating program. Some general principles for their preparation and use are suggested below.

Pre-Computation of Cost Data is necessary to prepare estimates quickly. Cost records of previous projects should be pre-digested and tabulated for immediate use. Although this advance computation, tabulation and plotting of data will produce some records which will never be used, directly worthwhile informative averages and general trends will be developed. As estimating methods and methods of keeping cost records become more standardized, it will also be possible to add published data to a company's record data and so gain useful information for the estimator.

Indexing of Cost Records is essential, even for identical projects, to compensate for the changes in general cost conditions between the periods when the two projects are built. It is usually desirable, therefore, to index all cost records to a common base in accordance with one or more of the published cost indexes. At this base level all the available information can be appraised and studied. Selected values for the project at hand can then be adjusted to the probable index value of the project.

Equipment Capacity-Cost Relationships exist for individual pieces of process equipment, and are somewhat more reliable than for overall plants. It is therefore desirable to maintain equipment cost records in capacity-cost form. Considerable valuable information of this type has been published.

Standardized Estimating Methods can only be used if cost records are made up in suitable form. This is accomplished in part by the use of the standard account sub-division system discussed below.

Organizing Cost Records for Estimates. The cost estimate for a modern industrial plant involves a multitude of features. It is absolutely essential to organize these into usable form. Costs of past projects must be collected and identified. These costs must be stored in such a way that they are easily available for new estimates. Also, a standardized system is indispensible for recording and using cost information if accountants and estimators are to have a common basis of understanding. Many account subdivision systems have been devised. The one which is used here has been tested in service and found to be well adapted to industrial use.

The following objectives need to be considered in establishing an account subdivision system:

1. A cost estimate account list should present a logical picture of the scope of the project. All major operating sections must be identified and listed in operating sequence.
2. Individual account subdivisions should identify the type of construction work involved.
3. Account subdivisions should be work units which can be easily segregated and identified in the field.
4. The list of standard accounts should be complete enough to prevent overlooking any major element of cost in the estimate.
5. The account system should be

adaptable for machine accounting to reduce the cost of obtaining and storing information for larger projects. (Eventually some estimating can be done automatically.)

6. The system should be as simple as possible, consistent with the number of units to be classified and the purposes which it must serve.

Also the system must satisfy requirements for property accounting, tax records, insurance premium computation and construction planning.

First, the project's cost estimate and cost records should be broken down into primary sections, each consisting of a major operating element of the project.

The titles of each primary section state in general the purpose to be accomplished by the installations in that section. Where possible, the sections coincide with operating departments or sub-departments. They are listed as nearly as possible in operating sequence. When common distribution systems, collection systems, utilities or buildings serve more than one section, they are listed in a separate section.

As an example, an account subdivision for a typical project might have the following primary divisions:

—10 Tank Farm Expansion
—20 Intermediate Cooling
—30 Tank Car Loading

The work in each primary section is broken down into subdivisions in accordance with the work description of a "Standard Account Subdivision List." Each subdivision is assigned a four-digit number. The first two digits from the left are from the "Standard Account Subdivision List," (See Table 1.)

The first digit classifies the work as to general type of construction involved, that is, structures, piping, electrical, etc.

The second digit further classifies, in more detail, the type of construction work involved. For example, if the first digit is three, the work is piping. If the first digit is three and the second digit is one, the work involved is steel piping (31-). If the first digit is three and the second digit is two, then the work involved is some type of alloy steel piping (32-).

The third digit is the primary section number and indicates the operating section involved, and is separated by a dash from the second digit.

The fourth digit is zero except when there is more than one item of a like classification in a primary section or when more than ten primary sections are required. In the later case, the numbers ten through fourteen, for example, can be assigned to one primary section and fifteen through nineteen to another. If more detailed division is required, a five-digit system with three digits in the second group can be adopted.

A complete account list on the four-digit basis for a typical project is as follows:

— 10 Tank Farm Expansion
13-10 Tank Foundations (6)

TABLE 1—Standard Account Subdivision List

Preparatory
01 Land purchase
02 Land leases and rights of way
03 Clearing site
04 Site fill and excavation
05 Temporary process connections and enclosures
06 Repairing, relocating and reconditioning existing structures and equipment, (Does not include modifications which increase capacity or efficiency.)
07 Project studies, owner's personnel
08 Project studies, associate engineer's personnel
09 .....

Structures
11 Subgrade improvements (piling, etc.)
12 Building foundations
13 Equipment foundations, concrete
14 Concrete grade slabs, pits, shafts, manholes, tunnels, and culverts
15 Building frames (with associated walkways and stairs)
16 Supporting frames, walkways and stairs (for tanks, equipment, piping, conduit, and cables, includes major supports only)
17 .....
18 Building enclosure (siding, roofing, floors, partitions, windows and other architectural items)
19 .....

Storage (including minor associated supports)
21 Gas and liquid storage, steel
22 Gas and liquid storage, nonferrous metal and nonferrous metal lined
23 Gas and liquid storage, nonmetallic, and nonmetallic lined
24 .....
25 Dry material storage, metallic
26 Dry material storage, nonmetallic
27 Ground storage (including dikes and dams)
28 .....
29 Insulation for storage facilities

Piping and Duct Work (including minor associated supports)
31 Steel piping
32 Alloy steel piping
33 Cast and wrought iron piping
34 Nonferrous metal, and nonferrous metal-lined steel piping
35 Nonmetallic, and nonmetallic lined, piping (including vitrified clay and concrete sewer piping)
36 Metal ducts and stacks for ventilation, gases and dust
37 Nonmetallic ducts and stacks for ventilation, gases and dust (including metal ducts and stacks with nonmetallic linings)
38 .....
39 Insulation for piping and ducts

Equipment (driving equipment and minor associated supports included with each)
41 Space heating, ventilating and air conditioning equipment
42 Plumbing and sanitary fixtures
43 .....
44 Office, laboratory, personnel and plant protection furnishings and equipment
45 Maintenance and repair equipment
46 Shipping containers and warehousing, shipping, packaging and container manufacturing equipment
47 Wells (but not well pumps or exploratory drilling)
48 .....
49 Insulation for both service equipment and process equipment

Equipment (driving equipment, and minor associated supports included with each)
51 Evaporation, condensation and isolated heat exchange
52 Electrolytic
53 Drying, burning and melting
54 Separation, filtering and screening
55 Reaction, adsorption, absorption, dissolving, and extraction
56 Size reduction, flaking, solidifying, densifying, crystallizing and mixing equipment
57 Dry and packaged material movement (including chutes and spouts)
58 Fluid movement equipment (including pumps, ejectors, compressors, blowers, and fans)
59 Instrumentation and control (with associated wiring and piping, does not include instrumentation or control for electrical power)

Electrical
61 Lighting (including fixtures, conduit, wiring, switches, lighting transformers and lighting panels)
62 Power generation equipment
63 Power conversion equipment (includes transformers, rectifiers and rotary converters)
64 Power control and metering equipment
65 .....
66 Power wiring and bus (including minor associated supports, insulators, conduit and ducts)
67 .....
68 (Reserved)
69 .....

Site Improvements
71 Ditching, finish grading and planting
72 Roads, parking lots, area surfacing and sidewalks
73 Railroads
74 Fence
75 Waterfront structures
76 .....
77 .....
78 Painting
79 Spare parts and equipment

Engineering Expense
Field
81 Field Engineering liaison
82 Survey—Layout
83 Survey—Property, topographic and hydrographic
84 Survey—Subsurface
85 Inspection
86 Testing

Design
87 Design Engineering (except studies)—owners personnel
88 Design Engineering (except studies)—associate engineer's personnel
89 .....

Construction Expense
91 Procurement
92 Construction equipment, tools and supplies
93 Temporary Facilities
94 Services
95 Administration and Fees

21-10 Storage Tanks (6 at 100,000 bbls.)
31-10 Piping, Tank Farm Area
61-10 Lighting, Tank Farm Area

—20 Intermediate Cooling
13-20 Heat Exchanger Foundations
31-20 Process Piping
31-21 Steam Piping
39-21 Insulation for Steam Piping
49-20 Insulation for Heat Exchangers
51-20 Heat Exchangers (2)
59-20 Instrumentation for Heat Exchangers

—30 Tank Car Loading
13-30 Loading Rack Foundations
13-31 Pump Foundations (3)
16-30 Loading Rack; with Stairs, Walkways and Bridges
31-30 Loading Piping
58-30 Loading Pumps (3)
61-30 Lighting, Loading Area
66-30 Power Wiring for Loading Pumps

Estimating Skill—The Essential Element. The last of the five factors affecting estimate accuracy is the skill of the estimator. Even though estimating methods are advancing to where their development and use can be called a science, the skill of the estimator is the essential element of any estimate. The techniques outlined above are far from being automatic. Each requires intelligent judgment in its application, and the skill, coolness and conscientiousness of the estimator will necessarily be reflected in the results.

Contingencies. Actual experience, when recorded in the form of an "over-run diagram," (See Figure 2), indicates that almost every estimate needs an allowance for contingencies —and that this allowance should be greater for estimates made before the definition of a project has been firmly established. However, an allowance for contingencies adequate to cover all mischances of past projects, would make most estimates much too high. And high estimates result in lost efficiency and other evils previously mentioned.

It is proposed that a contingency allowance be added to all "bare" estimates which will be more than adequate in, say, one out of every ten cases and somewhat less than adequate in the other nine. This allowance must necessarily be greater for the more poorly-defined projects. It can be represented by a sloping line, 0.06U in Figure 2, with one-tenth of the plotted points lying below the line. With a better estimating performance record, the line might have a slope of 0.03U. A "bare" estimate plus this minimum allowance for contingencies provides an excellent "target" estimate for the design and construction period. It is realistic, in that it accounts for "unlisted items" which are unknown or overlooked when an estimate is made. The allowance is slender enough, however, to encourage the designers and construction force to do their best to meet or beat the estimate and put the project in the "superior" classification.

Restricted Reserve. Not all of the projects will be superior. Some will be mediocre, some will be poor and some will be "dogs." These facts are shown in the Figure 2. A method is needed for advising management of the possibilities of over-runs if the project has misfortunes like those of previous projects.

For this purpose a "Restricted Reserve" can be established. This is the additional money which may be required for the project if almost everything goes wrong. This reserve must, as indicated by the "over-run diagram," be greater for projects of poor definition. It can be established, as shown by line 0.18U (Figure 2), that nine projects out of ten can be completed for the "target" estimate plus the Restricted Reserve. A better estimating performance record might reruce the line slope to 0.01U.

The possibility that all of the restricted reserve might be needed to complete the project is one of the factors management must consider in appraising its desirability. This possibility should also be considered in planning the financing and execution of the project.

The size of the restricted reserve can be appallingly large. Toward the right of the diagram the restricted reserve is almost as great as the target estimate. Under these conditions it is apparent that the estimate is very rough. Quite often this will result in further work to improve the definition of the project, e.g., further pilot plant work, checking the raw material analysis, taking foundation borings, making layouts, diagramming the utility system, or even making detailed drawings, before giving the project final authorization. Better project definition results from this engineering and can materially decrease the project's unknowns and correspondingly decrease the required restricted reserve.

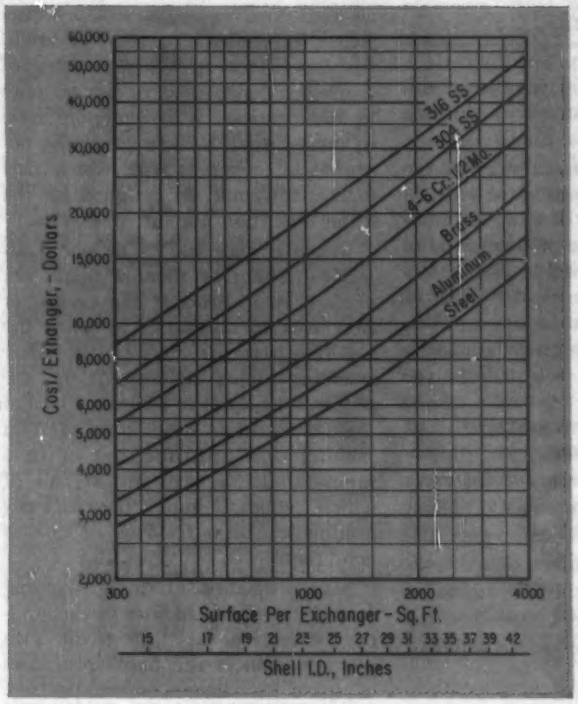
When making an estimate at any stage in a project's development, the size of the restricted reserve is an easily understood measure of the accuracy of the estimate. In this respect it is better than the nebulous labels of "preliminary estimate," "first estimate," "rough estimate" or "horseback estimate."

In Conclusion, this article is an outline of a rounded cost estimating system which combines features of existing practice with a few innovations. The application of such a system to the modern petroleum processing industry makes demands on the cost engineer which are well beyond the semi-clerical work which sometimes occupied estimators in the past.

Filling-in the detail of an estimating system and building up the necessary cost records requires time, money and patience. The rewards, however, in the form of reliable estimates, are more than worth the cost. Good estimates, available at any stage when they are needed in the development of a project, can flash the green light for projects which will be profitable, and the red light for projects which will be "dogs." By helping to keep a company in profitable projects they will return the cost of establishing and maintaining a good estimating system many fold. ##

About the Author

John W. Hackney is chief construction engineer for Diamond Alkali Co., Cleveland, where he has general supervision of cost and construction engineering work. He received his B.S. degree and his M.S. degree in civil engineering from the Carnegie Institute of Technology, and spent 11 years with the Aluminum Co. of America. Since joining Diamond Alkali 11 years ago, he has served in various cost and staff engineering assignments including responsible charge of the Houston works construction. Hackney is a member of numerous technical societies.



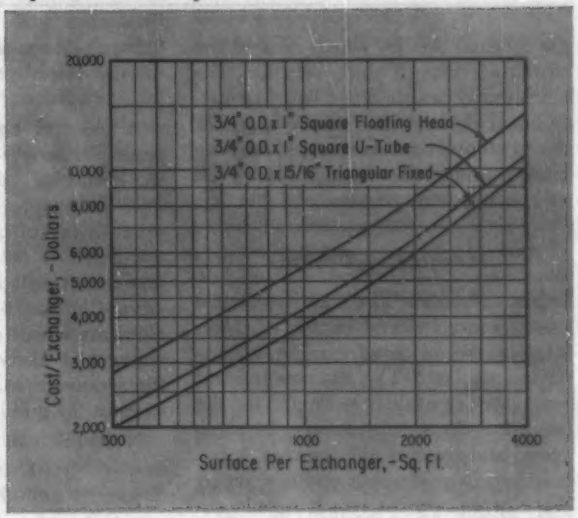


FIGURE 1—(Left) Here's how exchanger costs vary for various materials using split floating head construction at 150 psi pressure.

FIGURE 2—(Above) Exchanger costs vary in this manner for various types of construction. These costs are for all steel, 16-foot tubes and 150 psi pressure.

How to Save Money on Exchangers

Here are some design tips to include in your specifications for more exchanger, lower cost and less expensive operation.

Donald Q. Kern, D. Q. Kern Associates, Cleveland
Ralph E. Seaton, Wolverine Tube Division of Calumet and Hecla, Inc.
Allen Park, Mich.

SPECIFICATIONS are formulated by a purchaser to secure equipment which meets his particular preferences. Without specifications the purchaser would be obliged to make purchase analyses from among items which were not entirely comparable and which offered no standard for evaluation. In all probability the unspecified equipment would also represent the lowest first cost and cheapest method of construction—but not the most advantageous purchase for a given service period.

Most petroleum and chemical companies have compended rather extensive specifications to protect a majority of their local operating requirements. These are frequently compiled in a format consisting of isolated sections to permit revision by sections from time to time. When a revision is made, however minor, the whole section assumes the date of its latest revision.

Sometimes the dates on these sections appear fairly recent while reflecting basic articles and paragraphs committed to print 20 or more years ago without alteration or subsequent review. In fact some specifications are so old that they have become company traditions. No one challenges them since no one quite remembers who was around when the specification was originally written or the reason for the inclusion of restrictive clauses. The restrictive clauses thus continue ad infinitum, becoming as inviolable as a scripture from the Koran.

While one might have followed the paragraphs of such a set of specifications item by item in preparing this article, a different approach was taken. Assume one has never seen a set of specifications, or at any rate only peeked at a set, and proceed without an iota of inhibition.

There are two factors involved in the existence of every exchanger: first,

the thermal process which created the thermal design and, second, the mechanical design. Start with the mechanical design. This provides one of the best opportunities for wasting money under the questionable guise of conservative practice.

Mechanical Design

Expendability. The first question which must be answered is: How long is the piece of equipment expected to last? The average payout term for capital investment in the process industries nowadays is three years, and process obsolescence is figured roughly at about seven years. A piece of equipment which is only expected to last about three years is *expendable*, and one which is intended to last seven years or longer *non-expendable*. Intermediate life periods between three and seven years will usually resolve themselves through local conditions.

A piece of equipment may be expected to serve for only three years as the result of fast changing technologies in a given type of process or as a result of corrosion. In either event the result is the same—the piece of equipment will be used up. In such cases the use of mechanical design elements which gild a lily, if the exchanger is likely to be carted off to the scrapyard in three years—with or without the guild—cannot be justified.

No credit can be allowed for extra money spent on interchangeability, re-use in another process when the original process becomes obsolete, or provision for the future expansion of a process. The authors have seen too many examples of re-used equipment in revamped or expanded processes which precludes allowance of credit for farsightedness. When a piece of equipment is re-used or added onto another process it is generally used at only a small percentage of the potential effectiveness with which new equipment could be designed for the same operation and at lower cost.

When a spare old exchanger is attached to another, there is usually not enough static head at the pumps or flow area in the passes to allow the use of optimum velocities. After spending money to clean it up, the piece of equipment resurrected from the graveyard is either operated in parallel with another unit or in a series-parallel arrangement, all of which frequently impair the efficiency attainable with a fixed set of process conditions.

Standardization of design among four or five different sizes of exchangers also receives very little credit. This practice reduces the number of sizes of spare exchangers or bundles one requires if it is felt they are really required. Such occasions do arise in unsolvable corrosive services or dirty services such as coking. In most other services one frequently has to ask the question: Are spares really necessary? Where units are standardized, one is often obliged to select the next larger size rather than the optimum and cheaper size.

All of these elective preferences serve mostly to increase the cost of the original investment. Any financial officer will tell you that the best index of the use of money results in the purchase of facilities which pay out in the shortest possible period of time. This means buying *only* what you really need *when* you need it, at the lowest cost consistent with durability and reasonable maintenance. The more attention this credo receives among engineers the more rapid will be the expansion of the process industries and the number of projects available for engineers to engineer.

Material Selection. Next decide what materials are to be used on the streams handled. This is not a simple matter. If there is one or more corrosive fluids, refer to corrosion reference works such as Perry, Speller, or Lee and find one or more acceptable materials. These materials are then specified by their ASTM numbers with something of a feeling of studious con-

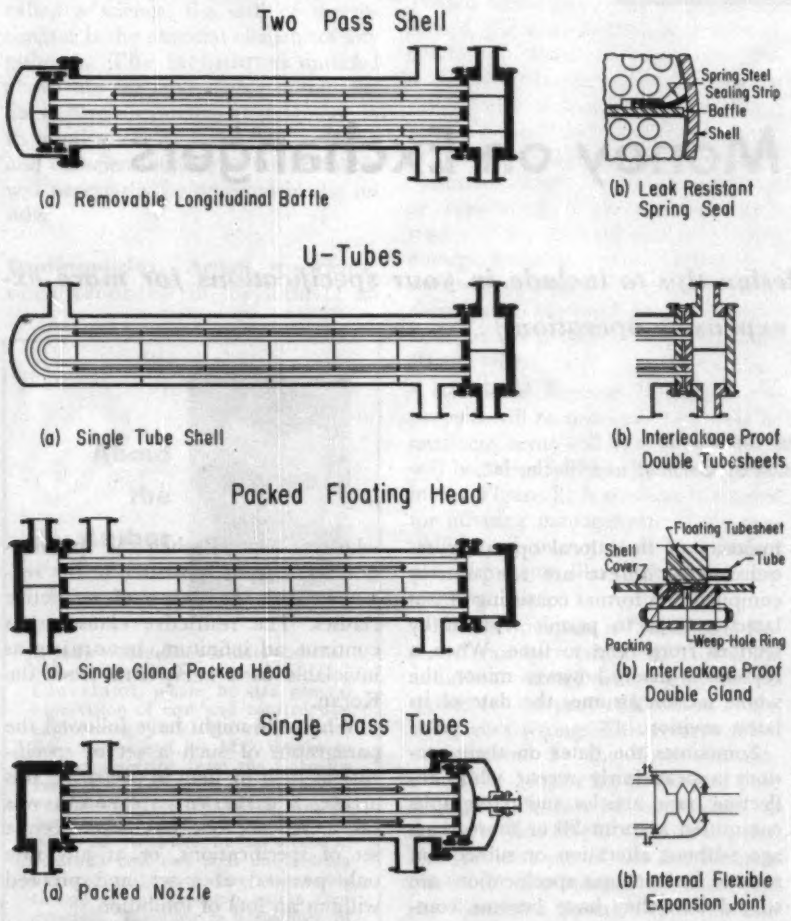


FIGURE 3—Here are some improvements upon old ideas that can save money in exchanger construction.

fidence. *However, it should be realized that the ASTM number is no warranty against corrosion.* The ASTM specification merely defines a tolerance in the chemical analysis of the metal which is intended to provide a limited tolerance in physical strength and durability. Thus, an 18-8 austenitic stainless steel with a given ASTM number may have an allowable chromium content of 16 to 18 percent by weight. The metal may be completely passive to a specific chemical attack when the chromium content approaches 18 percent, and be quite active when the chromium content approaches 16 percent. Either can be delivered within the terms of the same ASTM specification! Where service life is dependent upon a unique relationship of narrow limits between two or more metals or impurities, there is an infinite span of expectancies.

This imposes a serious problem when attempting to determine whether to spend more money on an alloy which has a longer prospective service life or less money on an alloy with a shorter prospective service life. This type of analysis would be rational if the conditions were always reproduceable, but there is no rigid way of assuring a definite amount of corrosion resistance simply on the basis of corrosion tables and ASTM number. Figure 1 shows the variation in exchanger costs with metal selection.

Caution is suggested relative to the use of corrosion tables which are reported as a loss in thickness in inches per year and which have been computed from a loss in weight. These tables do not always reflect close examination whether corrosion was uniform or pit-type. In the latter case one has no interest in the *average* loss of metal in inches per year—because the equipment becomes inoperative just as soon as the first pit-type pinhole appears on a tube. And remember—alloy tubes are usually very thin compared with the thickness of an alloy vessel.

In a corrosion-test vessel the reported temperature is that of the bath, and the solution may not be continuously changed or circulated. In an exchanger the solution is always fresh, the metal temperature may be much higher than that of the corrosive liquid being processed, and corrosion may be greatly amplified.

Having little or no experience with the handling of a particular polar chemical compound or solution, the best bet would be to start with the cheapest alloy which shows promise. Only after many installations have been made is it possible to effect a reliable refinement in the selection of alloys so as to justify a greater initial equipment cost.

There is one point to keep in mind, particularly when purchasing water-cooled units such as condensers or coolers. Most specifications and standards include a minimum allowable velocity for water and a maximum allowable water outlet temperature. *This does not assure protection against corrosion by water on steel or copper alloys.*

Corrosion does not occur in water-cooled services particularly because of the outlet temperature of the water. The hot water heater at home has probably been delivering 150 F. water for years without any maintenance. The most important consideration is the temperature of the tube metal at the outlet water pass of the cooler.

It is possible to have two coolers side-by-side, both using water at an exit temperature of 120 F. In one exchanger the tube wall metal in the outlet water pass may reach 145 F., and in the other the metal temperature may reach 175 F. It would not be improbable to have several times the corrosion maintenance cost in the latter unit. More about water later.

Codes and Standards

All equipment should be mechanically designed and constructed in accordance with the ASME 1956 Code for one of three reasons: First, the exchanger will be installed in a State in which it is mandatory when the design and operating conditions place it in categories defined by Paragraphs U-1 and U-2 or a State modification of the Code; second, when the insurer indicates a favorable insurance rate for code-constructed vessels; third, when wanting the peace of mind of well-constructed equipment.

Fundamentally, the Code only defines the envelope (shell, channels and heads) in which the tube bundle is assembled. It is possible to have a higher design pressure on the tube side, and a lower design pressure on the shell side such that a leaking tube could cause an elevation of the shell side above its safe working pressure. However, this situation would always be anticipated through the use of adequate pressure-relieving devices.

Some users insist that the safe working pressure of the shell side should not be less than some fraction, say two-thirds, of the safe working pressure on the tube side to take care of such a leak under static conditions. The higher pressure stream, in fact, is generally placed in the tubes because construction costs will be cheaper.

The API-ASME Code has become obsolete since the ASME Code was liberalized. However, in those states which do not have a Code requirement, the API-ASME Code will undoubtedly continue as a guide to construction for some time to come.

The Standards of the Tubular Exchanger Manufacturers Association have made a great contribution to the establishment of numerous practices which are either coincident with the Code or not covered by it at all. These Standards have brought together many elements which permit purchase evaluations on a relatively uniform basis. They have also originated and publicized many excellent design practices.

The TEMA Standards originally began as a rather conservative set of mechanical specifications, particularly for filling the requirements of the petroleum industry in handling combustible fluids. Specifications for this class are covered by TEMA Class R. Subsequently, two additional classifications were added: TEMA Class C for services which are not specifically intended for the petroleum industry, and TEMA Class A which has been developed for exchangers employing alloys.

The TEMA Class R exchanger is a rugged piece of equipment, with a minimum shell thickness of ⅜ inch starting with a 13¼-inch I.D. shell, and ½ inch starting with a 42-inch I.D. shell. The use of a minimum shell thickness which exceeds that computed for the safe working pressure represents insurance against distortion or puncture by falling wrenches, screw drivers, or an askance rap by a sporting crane operator.

However, a ½-inch thickness of

metal is considered in many quarters a large piece of insurance against punctures and dents. Other valuable contributions of TEMA are the standardization of flanges, tube sheet thicknesses, baffle leakage tolerances, baffle and support plate thicknesses, baffle and shell tolerances, and tube support spacings which suppress harmonics in the tubes and reduce tube damage due to vibration.

Whether choosing to use one of the TEMA classes or no class at all again reverts to the question of expendability. An exchanger which is going to last for many years and which is going to be pulled apart for cleaning and servicing on many occasions in its lifetime must be rugged. Otherwise, more trouble will originate with each servicing than the original cause for servicing, itself.

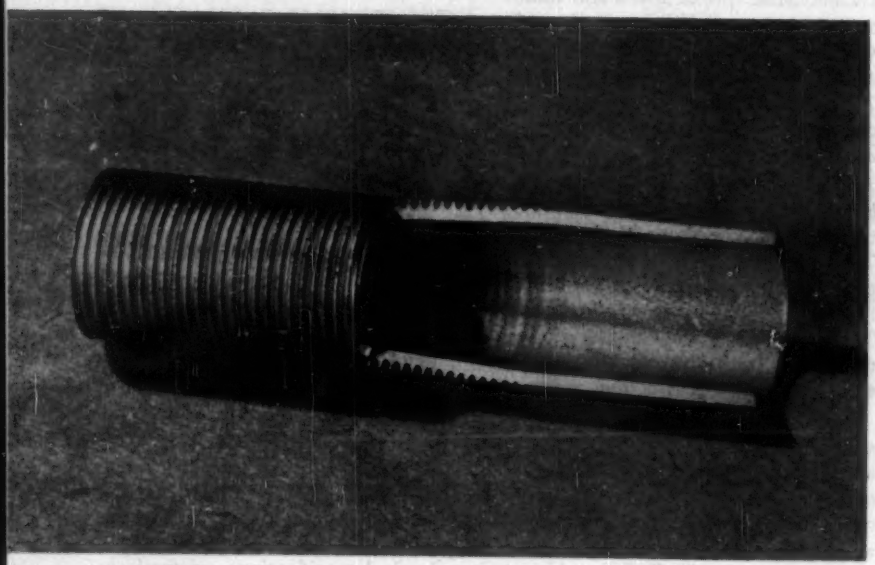


FIGURE 4—Typical low-finned exchanger tube showing bare end.

Where heat is to be exchanged with a corrosive fluid, it is desirable to circulate the corrosive fluid through the tubes so as to avoid chemical attack on the shell. When heat transfer occurs between two corrosive fluids, this alternative no longer prevails and the fluid which inherently requires the cheaper metal or produces the lower coefficient will be placed on the shell side.

It is a good practice to stay away from unusual metal combinations and fluids without past operating experience. A combination may be selected which converts the exchanger into a king-size battery. Cathodic protection of channels is feasible. But cathodic protection of the shell side has so far proved to be expendable.

Types of Construction

The floating head type of exchanger possesses three great advantages over the fixed tube sheet exchanger. *First,* it is capable of operating with fluids having long-temperature ranges and large-temperature differences because of its relative freedom for thermal expansion. *Second,* the bundle can be easily removed from the shell and the tubes cleaned on the outside. *Third,* the shell itself can be inspected for corrosion.

These again refer to the classification of expendability. Modern techniques have been developed for cleaning the shell side without removing the bundle through the use of detergents, steaming, acidulated washes, alkalizing washes and steamblasting with injected water droplets. Unless dealing with a fouling condition requiring brute force such as sandblasting, hydroblasting, or mechanically scraping, there need be no reason to withdraw the bundle from the shell during its lifetime. In such cases it is difficult to justify the use of floating head construction in any of its various forms. The tube side, generally speaking, presents no particular cleaning problems which are not identical in floating head and fixed tube sheet units. Packed floating-head exchangers will be discussed later.

Closely related to the floating head is U-tube construction. This is an ideal method of eliminating a floating head assembly, particularly with high tube side pressures, and is growing in favor. It has a drawback. The tube side fluid must not scale or deposit excessive dirt which might concentrate at the U-bends. It may be difficult to remove scale or dirt mechanically, even with the improved tube cleaners now available.

The fixed tube sheet type of construction is entirely adequate where there is limited differential thermal expansion between the shell and the tubes. When an organic liquid passing through the tubes is heated by steam in the shell, the differential thermal expansion between the tubes and the shell may be relatively small, depending upon the coefficients and average temperatures of the organic liquid and the steam. When the streams are reversed and steam is passed through the tubes, the shell may operate cold and the tube metal hot, providing increased differential thermal expansion for the same set of inlet and outlet temperatures and respective heat transfer coefficients.

There is nothing wrong, within limits, in having differential thermal expansion between the shell and the tubes since it only represents compression or tension on the metal. Certainly all of the common metals are well endowed for such services. However, there is a possibility of damage where the tube is rolled into the tube sheet and in multipass exchangers of bowing the tube sheet. Differential thermal expansion may be confined to a safe level when the tube metal stress does not exceed 9000 psi. In a 16-foot long unit made of carbon steel, this usually will not be exceeded if the log mean temperature difference does not exceed 100 F. Beyond this point, there is some question that damage will occur either at the tube roll or in distortion of the tube sheet or other stressed part. The relative cost of carbon steel exchangers in the three common types of construction are shown in Figure 2.

Fixed tube sheet units can be built

Cost-Saving Procedures—Two-pass shells with a longitudinal baffle, single tube and shell pass with packed floating head, broader use of triangular pitch, and use of low finned tubes.

with expansion joints of different types. The type of expansion joint which is made by cutting a piece of standard pipe in half and rolling it into a ring has only limited reliability. If the ring is made as heavy as the shell, it is questionable that it will flex. When the ring is extended by welding annular plate steel rings to increase the flexing arm, the cost of the expansion-joint rises pretty fast.

The bellows type expansion joints have been used in exchanger design work but not on a widespread basis. In some instances they have been attached to the shells of fixed tube sheet units. They have also been attached to a smaller internal nozzle rather than the large circumference of the shell, making a modified type of floating head.

As stated before, it is not recommended that expenditures for the purpose of achieving interchangeability between large groups of exchangers be made. While the element of interchangeability reduces the number of spares, it also boosts the first cost of the remainder of the equipment in a manner which is often difficult to substantiate.

Safe Working Pressure and Temperature

The safe working pressure and safe working temperature are usually selected in a conventional manner. The safe working pressure will represent an increase of about 20 percent or more over the operating pressure for the individual streams. The safe working temperature usually anticipates the precision of the temperature controller and will be a minimum of 50 F. above the highest temperatures of both streams.

In accordance with the ASTM Specifications for ferrous metals, the allowable stress has a constant value up to 650 F. Above 650 F. depreciations occur at 50 F. intervals, requiring heavier plate with higher design safe working temperatures. In the case of the cuprous alloys, the allowable stress starts to decrease as the temperature rises above 100 F. Naval brass has an allowable working stress of 12,500 psi at 100 F., while at 400 F. the allowable working stress is only 2000 psi. Excessive safe working temperatures become quite costly when using naval brass tube sheets.

Cost-Saving Procedures

At sometime or another nearly every manufacturer of heat transfer equipment has toyed with the idea of carrying standard off-the-shelf items which are mass-produced and available for immediate delivery. With the exception of relatively small items, this practice has not worked out.

If the units are to be carried in stock in a knockdown condition ready for assembly, the cost of carrying the inventory will probably offset any advantages derived from only partial mass production or volume buying. If the units are to be stocked completely assembled, then the manufacturer also has the cost of the assembly labor tied up. In carbon steel units this may represent 35 percent of the gross cost. For this reason few manufacturers carry any very great inventory of standard units or, for that matter, prefabricated parts.

One way of saving money arises through the use of certain elements of construction which have achieved fairly little acceptance. It's a peculiar aspect of the engineering business that one company will engage in a practice day after day which another company will not touch at all. The four types of construction shown in Figure 3 may well serve as examples.

Going back a long, long way, there has been a stigma attached to the use of two-pass shells. The fear of leakage around the longitudinal baffle was so great that the common method of fabrication was to weld the longitudinal baffle to the shell requiring use of a split floating tube sheet and cover. This usually increased the shell I.D. about 2 inches for a given number of tubes. By the time this fancy handwork was completed, the two-pass shell began to cost nearly as much as two single-pass shells with the same gross surface. What was more, there was a lot of opportunity for tube-side leakage at the split tube sheet, which exceeded in importance the loss of thermal efficiency about the longitudinal baffle.

Numerous vendors have had a lot of proficiency in attaching spring sealed longitudinal baffles to conventional floating head bundles, and many of these have been in service for years. In fact, the most popular patent expired several years ago. The two-pass shell represents an excellent economy when dealing with fluids possessing a temperature cross. The two-pass shell and two-pass tube modification is an excellent means of obtaining true counterflow where fluids have long temperature ranges.

Still another device which has found little favor is the one-shell pass, one-tube pass, floating head exchanger having a packed nozzle which passes from the floating head cover through the shell cover and is sealed by a packing gland. For some reason the petroleum industry, in particular, has never liked packing-glands on exchangers although they have no objection to their use in vastly more rigorous mechanical services.

The packed floating head exchanger is another type which has found little favor in the petroleum or petrochemical industries, although it has been used with reasonable frequency in the chemical industry. When used in the chemical industry, it serves as an excellent means for reducing the weight of alloy while obtaining the free expansion advantages of the floating head.

The broader use of triangular pitch can represent a sizeable economy. Many services have been observed in which the operation of the equipment was so clean that there was virtually no shell side service record for the equipment. When such is the case, there is no advantage in a preference for square pitch. Growing also in popularity is the use of the 20-foot tube and the ⅝-inch O.D. tube—both stemming from improvements in tube cleaning techniques.

A factor of considerable recent importance has been the widespread acceptance of the low-finned tube. A low-finned tube is one having plain ends of the same outside diameter as bare tubes but having 1/16-inch high

fins extruded along its length. Such a tube will have two and one-half times as much surface on the outside of the tube as a bare tube. In addition, low-finned tubes may be assembled in heat exchangers in the same manner as plain tubes and employ identical assembly techniques. The end of a low-finned tube is shown in Figure 4.

Very often the combined dirt and film resistances of one stream will be much greater than the other. The simple way to offset this difference is to have the stream with the highest combined film resistance and dirt factor exposed to the exterior of the low-finned tubes. It has already been reported[1] that low-finned tubes do not exhibit any preferential tendency to accumulate dirt. The total number of low-finned tubes required to provide the gross outside surface for a given service may be considerably smaller than the requisite number of bare tubes. In addition, there are the further savings which result from smaller shell diameters, heads and tube sheets which are required to enclose the smaller number of low-finned tubes.

Previously, most refiners turned to low-finned tubes as a means of eliminating a bottleneck in a particular service where throughput or dirt exceeded the original plan. For a while there was an attitude that new facilities might be built with bare tubes and when the time came for expansion it could be achieved by retubing with low-finned tubes. This, however, simply means that the facility was originally built with more money invested in tublar equipment than was necessary. Usable capital lay dormant where less could have been expended on a smaller finned-tube unit. Besides—who knows with any accuracy when a process will be expanded, if ever, and by how much.

Thermal Design

As seen in the preceding discussion it is possible to waste a lot of money on attitudes and opinions relative to construction without creating any definitive advantage.

The thermal design procedures in most companies are kept in an altogether separate book with explicit instructions on computation details. Here are some aspects of the picture which are not always written up in the design book.

Heat Recovery. The purpose of a heat exchanger is the recovery of heat. In some plants there is great compulsion to show a high degree of heat recovery as evidenced by small quantities of utilities per unit yield. The question is often asked: How much heat is really worth recovering?

In the production of heat the cost of the fuel is only a small part of the cost of the generating facilities for providing the energy. When attempting to recover too much heat, there are invariably smaller and smaller temperature differences. To recover heat under a small temperature difference means that a large sum of money must be invested in heat transfer equipment per BTU recovered. Very often it would be cheaper to waste heat if it is present in a fairly viscous petroleum steam. It would be cheaper to provide utilities for preheating a cold stream with low-pressure steam with a much greater temperature difference and higher over-all heat transfer coefficient than that attainable through recovery.

There are, of course, numerous optimum design equations to guide in the useful recovery of heat. These have usually required component costs for such items as utilities, maintenance and surface which are not always available with any degree of precision. These equations also require lengthy trial-and-error solutions. However, equations can now be developed which are readily amenable to computer solutions.

There is a lot of money to be saved through the cautious selection of temperature differences. In a way this is directly related to the preceding comment but merits the additional analysis which establishes that a BTU which must be removed at a lower temperature difference is worth considerably less than a BTU removed at a large one.

Fouling Factors and Over-Surface. There is no single tool which is more abused and which costs the process industries more money annually than the conventional use of fouling factors. As originally tabulated, fouling factors were units of resistance which were intended to secure a period of operation prior to the deposition of dirt such that the desired outlet temperatures of the two process streams were no longer attainable.

These values were originally classified by rather narrow process services. By-and-large, they were uniform whatever the feed stock and whatever the actual method of operation. Since the fouling factor is a fixed resistance, it has no way of changing with time. It exists or it doesn't, but it has no way of growing. Consequently, no one has offered a rational interpretation of how long a period of service one should expect from a unit of fouling factor or that two units of fouling factor are a definite multiple of one unit. In the final analysis, the fouling factor is a means for making the exchanger larger than it need be if it were clean but which is related to performance only by classification.

A fouling factor does not always accomplish this end, and an increase in the fouling factor can actually result in a decrease in the service life of a piece of equipment. Consider a light-ends overhead condenser which condenses a vapor from 130 to 100 F. when supplied with cooling water at an inlet temperature of 85 F. A substantial part of the condensate returns to the column as reflux.

Consider the quick appearance of a winter cold wave. The temperature of the inlet water may drop as low as 55 F. Assuming the same approach at the outlet of the condenser, the outlet temperature of the condensate will drop from 100 F. to 70 F.

Soon someone discovers something is wrong. The subcooled trays below the reflux will fail to rectify, and there will be an increased demand on the reboiler. To get the condensate temperature back up to 100 F., there is but one quick method, and that is to cut back the flow of water.

Water which is silty has a tendency to deposit its solids on the inside wall of the tubes as some inverse function of the linear velocity of water. The condenser may have been designed originally to operate with a minimum velocity of 3 feet/second, but now

Keep out of trouble—Avoid heat recovery exchangers with very small temperature differences and don't be fooled by using the old outdated fouling factors.

during the cold wave it has been reduced to only 1 foot/second. The deposition of dirt may be so rapid at the lower velocity that within a few days someone notices that the unit now no longer delivers the required heat load even though the water flow is temporarily increased.

At some later date another expansion is planned at the same refinery, and someone remembers the difficulty they had with the condenser referred to above. Instead of allowing a 0.001 or 0.002 dirt factor as they had previously, it is decided to double the water dirt factor for extra protection. This means that there is now so much extra surface available that the water temperature will not have to get down to 55 F. in order to initiate throttling. With the aid of the extra surface the condensate can approach 70 F. when the inlet water temperature is only 60 F. This produces a longer operating period at reduced water velocity to promote the accumulation of even more dirt.

Whether it is water or any other fluid, it must be realized that the fouling factor manifests itself as excess surface. For two streams of given sizes, the greater the amount of surface the greater the possibility of difficulty in maintaining high linear velocities for each. All evidence seems to indicate that high velocity is the principal factor in keeping heat transfer surface clean. Therefore, the use of an *excessive* fouling factor can reduce the period of service. Of course, factors which are *excessive* are only used when the proper values are not known. Greater cognizance of this point might result in a vastly larger literature on operating rather than hypothetical fouling factors.

For water or any other fouling fluid, excluding corrosive attack, there is a minimum velocity at which the unit can be operated for an extended period of time. Unfortunately, this can not be attained when following the convention of allowing the same pressure drop for each stream per exchanger. If one stream is assigned a dirt factor of 0.002, and another is assigned a dirt factor of 0.004, and if a relationship between velocity and fouling maintains, it is fundamentally wrong to subject these two streams to the same pressure drop allowance. They are obviously very different in character. Extra surface to accomodate these differences is allowed, but rarely different pressure drops are allowed so that both streams might perform with the same effective dirt factors. One might, in fact, use a single fouling factor for all streams and actually obtain equivalence through the economic use of static head.

The cost of furnishing extra static head for the circulation of an incompressible fluid is usually relatively inexpensive. Unfortunately, in equipment design the cost of a single day's downtime is not considered. What does it mean to pull several million dollars worth of facility out of service while a part is cleaned? How much would it be worth if it did not have to become fouled in the first place and could have been avoided at a fraction of the cost of the downtime?

Where a problem of severe corrosion or dirt does exist, there is no intention to minimize it. If it will not respond to reasonable increments of velocity, the use of 100 percent standby units is suggested, if there is no better solution to the problem than the total standby.

Overcapacity or oversurface is another item whose merit must be questioned. When a group of exchangers is designed for overcapacity, the heat loads and the fluid quantities are multiplied by an overcapacity factor representing some future anticipated expansion. However, until the plant is actually expanded a sum of money is tied up for an indefinite period of years in equipment which is too large. Most overcapacity factors cause enormous extra surface allowances on top of fouling factors, so that the case of excessive fouling factor is amplified even more.

Occasionally the overcapacity factor will be used to offset uncertainties in design. Such cases are usually identified by the fact that the factor varies from item to item. This point is best resolved by a comparison of the cost of experimentation for the purpose of improving certainty against the cost of extra facilities. How uncertain should a process be if a plant will be built around it?

Last—each exchanger is not an unique affair of design and construction. However, there is a tendency to evade the factors of design and operation which will simplify it. Because an exchanger can recover many times its cost annually as heat, it gets the benefit of all doubts. But a pump—which is often more complex—has no way of making money. It can only pump—and it is bought from a catalog—but it is just as essential to continued operation.

LITERATURE CITED

[1] Kern, D. Q., Chemical Engineering, 63, No. 9, P. 189-191, 1956

About the Authors

Kern

Seaton

Dr. Donald Q. Kern graduated from M.I.T. and the Polytechnic Institute of Brooklyn. He formerly served as process engineer for the American Molasses Co.; process engineer and department manager in heat application, Foster Wheeler Corp.; and director of engineering, Process Engineering division, The Patterson Foundry & Machine Co. From 1943 to 1953 he was a professor of chemical engineering at the Polytechnic Institute of Brooklyn, where he was in charge of advanced instruction in heat transfer and thermodynamics. Dr. Kern now heads D. Q. Kern Associates, a thermal design and application organization.

Ralph E. Seaton is technical sales supervisor for Wolverine Tube Co., division of Calumet & Hecla, Inc. A mechanical engineering graduate from the University of Detroit, he worked in allied fields prior to joining the Technical Sales department of Wolverine in 1955. He spent 1956 and 1957 as technical sales representative in the New York area for Wolverine Tube. He is now in charge of technical products sales to the processing, power, and nuclear energy industries.

W. L. Gore*

W. L. Gore and Associates
Newark, Del.

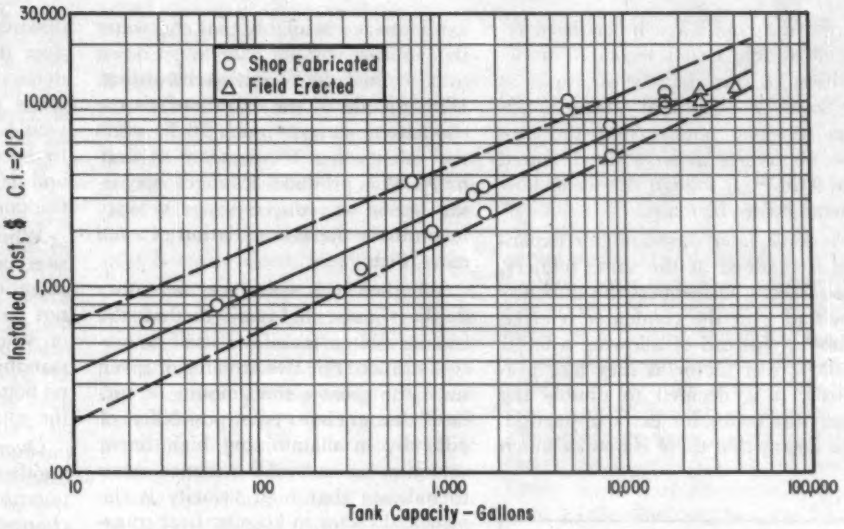


FIGURE 1—Cost of stainless tanks varied like this. Notice that shop and field erected tanks are included. All data based on tanks installed vertically at ground level, for atmospheric pressure service, without insulation, tracing, or heating coils.

How to Improve Estimate Accuracy

Proper appraisal of uncertainties in estimates can save time and money when making cost studies. Many times high-spot estimates will do the job.

COST, PROFITABILITY, and many other kinds of estimates are made to guide business decisions. Unless some present or future action will be influenced by the outcome of an estimate, time should not be wasted in making it.

The accuracy and reliability required in an estimate should be gaged by the regret associated with a wrong decision based on it. These regrets may range from those arising from the improper abandonment of a speculative line of research having only a minimal probability of success, to the acutely painful regret of building an unprofitable multi-million dollar plant. An appraisal of the likelihood of such regrets should be an integral part of all estimates, and this is accomplished most directly by establishing boundaries within which the actual situation will almost certainly be established.

Commercial estimates are predominately based on enginering calculations, but a wide variety of disciplines are required, particularly in estimates of profitability. However, the purpose here is not to discuss these disciplines, but to outline objective techniques for establishing boundaries on estimates be they of whatever kind. Such boundaries are ultimately based on judgment. Therefore, the primary requirements of a satisfactory technique for establishing boundaries of reliability are that the sharpest possible judgment be brought to bear on each facet of the estimate and that this judgment be propagated through all the complexities of the manipulations with a minimum of distortion.

A number of proposals have been made for procedures to calculate limits on estimates, most of which are based on either "probability" or on "experience factors." Other approaches have been to classify estimates as "preliminary", "order-of-magnitude", "final", etc., depending on the stage of development and number of previous estimates. Most attention has been given to estimates of operating costs and of capital cost of construction, while very little attention in published works is devoted to other types of estimates equally important to profitability.[1]

* Formerly with E. I. duPont de Nemours and Company, Inc.

Estimating Uncertainties

It is most important to recognize that any estimate is associated with a plan and that deviations from the specified plan result in deviations in the estimate. This requires precise defination of the plan on which the estimate is based, but does not omitt appraising the consequences of deviations from the plan and the likelihood of encountering such deviations if and when the plan is carried out.

In estimating capital investment in a chemical plant utilizing a new process, the estimate is based upon a plan defined, among other things, by the process flow sheet. Here the size of streams, quantities of materials treated, utilities required, etc. are set by both the chemical yields and conversions and by the engineering bases and methods. The design specifications of the equipment pieces, instrumentation, and piping, etc. depend upon both the "plan" and upon engineering judgment. One common deviation from plan is the subsequent discovery that needed equipment or facilities have been left out.

Estimating ingredient costs, operating costs, depreciation charges, technical assistance expenses, is also based on a specified plan that is likely to undergo deviations when carried out. Selling expense, volume of sales versus time, and selling price are critical quantities affecting profitability and their estimation is again based upon a plan that is not only likely, but almost certain to suffer deviations.

In addition to the uncertainties arising from engineering methods and from deviations from the specified plan or basis of an estimate, a further uncertainity is found in converting the equipment pieces, ingredients, utilities, and men into dollars. This conversion may be made either on the basis of quotes or on the basis of historical records of previous constructions and operations, adjusted for expected trends in construction cost index, wages, and procurement difficulties. Large uncertainties are encountered in this translation into dollars. In Figure 1 are plotted the purchase-plus-installation costs of a number of stainless steel tanks of similar geometry, construction, and wall thickness, differing only in size. The historical variation in cost of the same type of tank is very large, making it very uncertain how much a specific tank is going to cost.

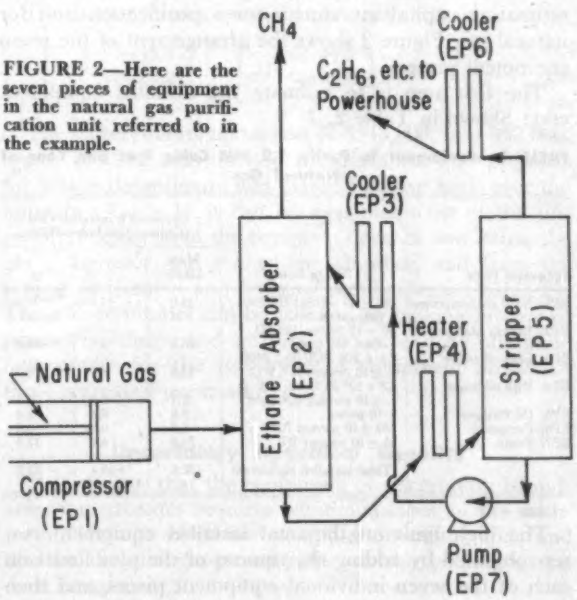


FIGURE 2—Here are the seven pieces of equipment in the natural gas purification unit referred to in the example.

It is indeed fortunate that all uncertainties in a complex estimate are not additively accumulative, for this would reduce estimating to shear guess-work. In unbiased estimating, many of the plus and minus uncertainties cancel each other and this "compensation of errors" gives an additive result that is much more reliable on a percentage basis than its components.

Estimating Principles

Maximum discrimination is achieved when the field or area to be estimated is narrowed to the greatest practical degree. This is because more specific and precise information can usually be obtained on the components of an assembly than on the assembly itself, and because of the "compensation" that occurs when the design and cost uncertainties of the component parts are allowed to offset each other in adding up the parts to get the whole. Many estimates considered "impossible" when viewed as a whole, yield with surprising ease to a detailed-breakdown approach and can be bracketed with unexpected precision.

A useful technique for avoiding bias is to establish first the minimum and maximum figure for a quantity or cost and only after this has been done, judge the most likely figure. This procedure opens the way to estimate any conceivable quantity; and if enough components are added together to obtain a decision value, very often the precision is at least adequate to give useful guidance.

Propagation of Uncertainties

In order to take advantage of the improved discrimination of a detailed breakdown of a proposition for estimating purposes, it is desirable to be able to propagate the effects of the minimum and maximum judgment of the various components upon the resultant estimate of the decision quantity, such as project cost, mill cost, annual earnings, return-on-investment or whatever. Unfortunately, there is no precise way of doing this. Statistical mathematical theory is not applicable, for we are dealing with "uncertainties" not with probabilities, fiducial distributions, or constant-cause mechanisms. (Although statistical methods are extremely useful in many of the parts of estimates where boundaries, correlations, and significant differences can be most efficiently determined by these methods).

Nevertheless, a quite satisfactory method for propagating uncertainties is available if the component parts of an estimate are carried out using procedures that satisfy the following requirements:

1. The quantity or value assigned to each component is the one *most likely to be correct.*

2. There is *equal likelihood* of the correct quantity being greater than or less than the most-likely quantity.

3. There is an *equal likelihood* of the correct quantity being as low as the minimum or as high as the maximum limit.

4. Each component in the estimate is so set up that it is *independent* of (unaffected by) the other components. (e.g. a yield uncertainty carries with it a concomitant uncertainty in ingredients and investment, etc. Therefore yield and all things affected by it must be treated as a single

entity in summing up for mill cost, capital investment, and the like.)

Then the *most-likely* figure for the estimate is derived from the most-likely figures for each component (usually the sum of the components). The upper boundary is calculated by treating the positive deviations from the most-likely figure to the upper limit as though it were a normal deviate with full opportunity for compensation, and the lower boundary is calculated (separately) in the same way.

Specifically, let: $E = f(A, B, C,—)$, (1) where E is the resultant estimate, A, B, C,—are components, and $\pm a, \pm b, \pm c$,—are the deviations of A, B, C,—from their maximum and minimum limits.

Then the uncertainty boundaries of the estimate $(E + e, E - e)$ are calculated from the partial differential equations

$$E + e = f(A,B,C\text{---}) + \sqrt{\left(\frac{\partial f}{\partial A}\right)^2 (+a)^2 + \left(\frac{\partial f}{\partial B}\right)^2 (+b)^2 + \left(\frac{\partial f}{\partial C}\right)^2 (+c)^2 + \text{---}} \quad (2)$$

$$E - e = f(A,B,C\text{---}) - \sqrt{\left(\frac{\partial f}{\partial A}\right)^2 (-a)^2 + \left(\frac{\partial f}{\partial B}\right)^2 (-b)^2 + \left(\frac{\partial f}{\partial C}\right)^2 (-c)^2 + \text{---}} \quad (3)$$

If the estimate E is obtained by simply adding together (or subtracting) the components A,B,C, the uncertainty in the estimate is given by the root-mean-square of the component deviations

$$+e = \sqrt{(+a)^2 + (+b)^2 + (+c)^2 + \text{---}} \quad (4)$$

$$-e = \sqrt{(-a)^2 + (-b)^2 + (-c)^2 + \text{---}} \quad (5)$$

Other useful uncertainty equations can be obtained from (2) and (3). For example:

Average:

$$E = \frac{A + B + C\text{---}(\text{N items})}{N}$$

$$+e = \frac{\sqrt{(+a)^2 + (+b)^2 + (+c)^2 \text{---}}}{N} \quad (6)$$

$$-e = \frac{\sqrt{(-a)^2 + (-b)^2 + (-c)^2 \text{---}}}{N} \quad (7)$$

Multiplication:

$$E = (A)(B)$$

$$+e = \sqrt{B^2(+a)^2 + A^2(+b)^2} \quad (8)$$

$$-e = \sqrt{B^2(-a)^2 + A^2(-b)^2} \quad (9)$$

Division:

$$E = A/B$$

$$+e = \sqrt{\frac{(+a)^2}{B^2} + \frac{A^2(+b)^2}{B^4}} \quad (10)$$

$$-e = \sqrt{\frac{(-a)^2}{B^2} + \frac{A^2(-b)^2}{B^4}} \quad (11)$$

Mathematical Basis

The procedure outlined above would be rigorously correct if—

1. The limits of the component figures were probability points for a normally distributed variate.

2. The limits were all set at the same probability level and,

3. Each component were independent of all other components.

Unfortunately none of these conditions are met. Uncertainties not probabilities, are being propagated and such uncertainties (like all real quantities) have no rigorous meaning in mathematical symbolism. There is only incomplete information on the expected distribution of quantities, but it is known that most of them are not normal and many of them are discontinuous. Even the discrimination of independence is sometimes difficult.

Validity of Propagation Procedure

In spite of mathematical difficulties, the propagation appears to work well. Most of these difficulties would tend to give overly wide uncertainty boundaries by this procedure, though this bias is minute and probably not significant. A somewhat more puzzling question is the degree to which unsymmetrical boundaries in the components of an estimate lead to bias in the "most-likely" figure for the estimate. However again it is felt that this is probably a minor matter from a practical point of view.

Experience has been gained in using the uncertainty propagation procedure in several hundred estimates, a number of which have been proved-out in actual operations, and none of which have been found incorrect within the framework of the plan used as a basis for the estimate.

Example of Uncertainty Calculation

The application of the uncertainty appraisal method can be illustrated by considering the very simple case of estimating capital investment for a purification unit for natural gas. Figure 2 shows the arrangement of the seven equipment pieces.

The first step is to estimate the installed equipment cost: Shown in Table 2.

TABLE 1—Equipment to Purify 1.2 MM Cubic Feet per Year of Natural Gas

Equipment Piece	Design Basis	Thousand $ Installed Cost (Construction Index-212)*		
		Most Likely	+	−
EP1: Nat'l gas compressor	168 ±10 percent HP,550 psig., steel +5	49.0	11.0	20.0
EP2: Ethane absorber	30 —19 plates, 19" ID, steel, 350 psig.	36.0	9.0	23.0
EP3: Lean oil cooler	2.8 x 10^6 PCU/hr., 2500 ±10 percent ft.², 0°C	12.8	3.0	1.5
EP4: Rich oil heater	2.8 x 10^6 PCU/hr., 320 ±10 percent ft.², steel	2.1	0.6	0.6
EP5: Oil Stripper	5–10 plates	3.9	0.4	2.0
EP6: Condenser	250 ±10 percent ft.²	1.8	0.6	0.6
EP7: Pump	55 ±10 percent HP	24.0	5.0	13.0
	Total installed equipment	129.6	+15.4	−33.2

* 1939 = 100

The high limit on the total installed equipment cost was obtained by adding the squares of the plus limits on each of the seven individual equipment pieces, and then

"Statistical mathematical theory is not applicable, for we are dealing with 'uncertainties' not with probabilities, fiducial distributions, or constant-cause mechanisms."

taking the square root of this sum; the lower limit was obtained by a similar treatment of the minus limits [Equations (4) and (5)].

The battery-limit investment for this gas purification plant will include such things as piping, instruments, buildings and the like. These can be estimated from experience factors for similar kinds of equipment. The factor by which the total installed equipment cost should be multiplied for the additional costs are shown in Table 2.

TABLE 2—Multiply Installed Equipment Cost by These Factors for Total Plant Cost.

ITEM	Factor	+	−
Piping	.50	.25	.25
Instruments	.25	.15	.15
Buildings	.31	.13	.13
Outside Lines	.08	.04	.04
Engineering Costs	.45	.05	.05
Misscellaneous	.06	.04	.04
Total Factor	1.65	+.33	−.33

Again the limits on the total factor (Table 2) were obtained by taking the root-mean-squares of the deviations. [Equations (4) and (5)].

The investment for these items is computed from the product of the total factor and the total installed equipment cost:

$$(1.65 \pm .33)\left(129.6 \begin{matrix} +15.4 \\ -33.2 \end{matrix}\right) = 214 \begin{matrix} +49.8 \\ -69.6 \end{matrix} \quad \text{M\$}$$

The limits were calculated from equations (8) and (9).

$$+e = \sqrt{(129.6)^2 (.33)^2 + (1.65)^2 (15.4)^2} = 49.8$$

$$-e = \sqrt{(129.6)^2 (-.33)^2 + (1.65)^2 (-33.2)^2} = 69.6$$

The battery-limit capital cost is then:

$$\left[129.6 \begin{matrix} +15.4 \\ -33.2 \end{matrix}\right] + \left[214 \begin{matrix} +49.8 \\ -69.6 \end{matrix}\right] = 343 \begin{matrix} +52 \\ -77 \end{matrix} \quad \text{M\$}$$

The battery-limit capital cost of $343,000, plus $52,000, minus $77,000 may be too uncertain for the purposes for which the estimate was made. Looking back over the estimate (Table 1) it can be seen that most of the uncertainty arises from the equipment cost of two items, the gas compressor and the ethane absorber, and from the piping, instrument and building requirements (Table 2). These uncertainties can be reduced by making layouts of piping, buildings, and instrumentation and by obtaining firm quotes for the two items of equipment on which there is greatest uncertainty.

Uncertainty Appraisal Benefits

It is obvious that the computing of uncertainty boundaries for estimates requires additional labor in the arithmetic, (though electronic computers mitigate this) and also in the thought-processes to set the boundaries on each component.

This additional labor and thought-effort must be offset by advantages gained by using the system, or it is not worthwhile. Benefits may be gained in the following ways:

1. A preliminary high-spot estimate may suffice, and the labor of a detailed estimate saved. This can be judged by questioning whether different actions will be taken over the range of the high-spot estimate from the lower to the upper boundary.

2. The reliability of a preliminary estimate can be improved very efficiently, for the uncertainty estimates "put the finger" on the few areas from which most of the uncertainty arises. Usually a relatively small amount of work in these areas will give a great improvement in the reliability of the estimate.

3. When several estimates are brought together for decision purposes, boundaries on the estimates direct attention to those estimates most critical to the decision. For example a cost-of-manufacture estimate may have insignificant uncertainty compared to a selling-cost estimate. A cost-of-sales estimate may be extremely precise when compared to an estimate of product-value and hence of attainable selling price. In these situations, the uncertainty boundaries permit a valid managerial decision to be made on which areas need to be firmed-up before making a business commitment.

4. Boundaries on estimates setup a general atmosphere in which attention is focused on the quantitative aspect of estimates, and a clear separation is made of non-quantitative factors. Under these circumstances the risks associated with decisions are objectively appraised and actions are taken without undue hesitation or faltering.

5. An appreciation is gained by all concerned that there are no precise and unvarying "facts" and attention and effort is directed toward using available resources to obtain the most pertinent information.

It will be recognized that the concept of quantitative appraisals of uncertainty has philosophical and phychological as well as procedural implications. It may be that these are more important than the strictly systematic aspects of the procedures.

LITERATURE CITED

[1] Industrial and Engineering Chemistry 48, 934-42 (1956) Ibid 49, 936-46 (1957).

About the Author

W. L. Gore is president of W. L. Gore & Associates, Newark, Del. After graduating from the University of Utah with B.S. and M.S. degrees he gained experience in chemical engineering development, plastics research, and statistical methods and experimentation. Prior to January, 1958, Gore was with Du Pont Co. heading an Operations Research group in the Polychemicals department, Research division, where he was senior supervisor of the Staff section.

Process Evaluation From Lab to Plant

Here's a step-by-step example of the application of process evaluation from research laboratory through engineering to the completed plant.

R. L. Buchanan
E. I. du Pont de Nemours and Company, Inc.
Wilmington, Del.

TODAY'S fierce competition does not permit sequential application of chemical, engineering, and economic skills. If a new venture is to have any chance of success, process evaluation must be applied at every step during its development.

Don't be confused by the term Process Evaluation. It's only a fancy name for "Find Out What Things Cost Before You Buy Them."

Now, how to use process evaluation? Actually it's merely a semi-formal application of specialized skills in process economics and engineering technology. In the past, the chemical industry has tended to complete a chemical process development in the laboratory before consulting the engineers about scale-up to an economic production facility. While this has led to operable processes and even to ones which have made money in a less competitive economy, the fierce competition of today does not permit sequential application of chemical, engineering, and economic skills. In today's climate, this pattern of chemical process development is no more logical than would be the engineering design of complete plant facilities followed by a chemical laboratory development aimed at finding a product which could be economically manufactured in these facilities.

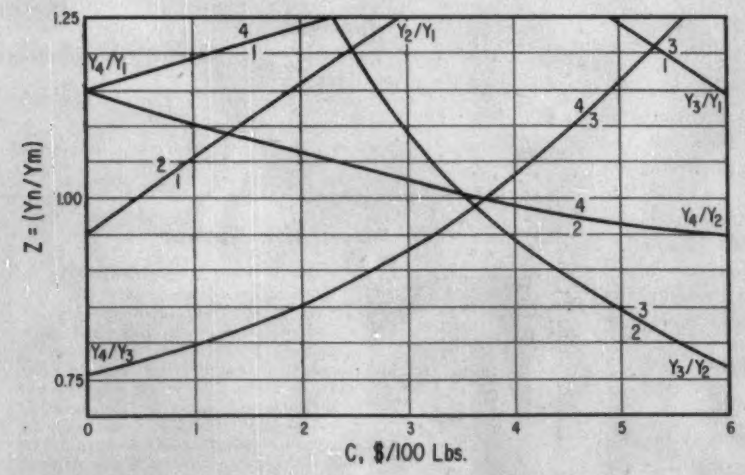


FIGURE 1—The ratio of yields (Z) for any two reactions will give break-even price for material C. Numbers on either side of each line show which reaction is cheapest.

First examine the research and development stages of a new product or process to see what we should expect of this tool, process evaluation. Generally the development chemist will determine the alternative chemical routes available. He will inquire into availability of raw materials for the various routes and determine from literature references and experiments the yield for each route. Ideally, a route will then be chosen utilizing abundant low priced raw materials which give high product yield. Calculations will be made to indicate the balance between raw material prices and yields. Catalyst cost and catalyst life are also considered in this preliminary economic balance.

However, the chemist must have broad knowledge of his own field. He cannot spare time to explore further economic factors. All his effort must be devoted to determining optimum conditions for the selected process in terms of time, temperature, pressure, concentration, catalyst, etc., and in product evaluation. He will generally shy away from routes involving a large number of separate processing steps. because of the inherent costliness of many-step processes.

No amount of engineering or eco-

nomic process evaluation can be substituted for this type of analysis by the research chemist. However, process evaluation can supplement these activities in very valuable ways. An engineering analysis of the proposed processes, involving preparation of material and energy balances, permits a quantitative analysis of such factors as temperature, retention time, reaction pressure, and conversion. Purification problems are expressed in terms of sizes of filters, distillation columns, adsorbent beds, etc. Such an analysis indicates the factors to which process economics are particularly sensitive and can direct research attention to items of top priority from an economic standpoint.

In many cases, high yield and low material cost for a process will be offset by high investment in processing equipment. Cost of utilities such as steam for distillation or stripping may also be high, resulting in a better over-all economic picture for the process which consideration of raw material and yield alone would have ruled out.

Current literature frequently refers to the effectiveness of research teams consisting of specialists trained in various scientific fields. Such teams permit the solution of problems which cannot be solved with the knowledge and methods of one scientific field. Process evaluation carries the team approach one step further by adding specialized engineering and economic skills to the purely scientific research skills.

Process evaluation can best be illustrated by this synthetic case. Assume an interest in producing a new product utilizing an intermediate X. Market analysis indicates sales of this new product of approximate 20 million pounds per year if selling price were held to $1 per pound. Intermediate X is commercially available in relatively small quantities at 50 cents per pound but integration of intermediate manufacture with processing facilities for the new product appears worthy of investigation.

The problem facing the research chemist is to develop a process for the economic production of high quality intermediate *X*. His first step is to search the literature to find out what is known about this compound. This search reveals—

a. *X* is manufactured commercially by the reaction

$$A + B \rightarrow X + C \qquad (1)$$

b. Laboratory preparations of *X* have been carried out by two other routes.

$$B + C \rightarrow X + E \qquad (2)$$

$$F + E \rightarrow X + C \qquad (3)$$

c. The commercial reaction (1) is reported to give 80 percent yield. No information is available on yield for reactions (2) and (3).

d. There appear to be no patents which would preclude use of any of the three routes to *X* but this should be reviewed after the preferred route has been tentatively selected.

Calculations of raw material costs based on an assumed 80 percent yield for all routes and current market prices for raw materials and by-products show the following:

	$/100 lb. X	
	No By-Product Credit	Full By-Product Credit
(1) A+B→X+C	10.90	9.42
(2) D+C→X+E	11.93	11.93
(3) F+E→X+C	17.80	13.36

Reaction (1) appears to have a fairly clear-cut economic advantage over the other routes to *X*. However, considerable research effort will be required to develop the selected process, so extreme care is necessary in making the selection. Since reaction (3) produces compound C which reaction (2) consumes perhaps the two could be integrated to give:

$$D + F \rightarrow X + E \qquad (4)$$

Comparable raw material cost figures for reaction (4) show $12.29 per 100 pounds of *X* at 80 percent yield. Still no competition for reaction (1).

However, all calculations have been based on assumed yields and purchase price or by-product credit for compound *C*. How sensitive to these variables is our comparison? In order to answer this question (without the need for a computer or even a three-dimensional mathematical model) equations for the unit raw material cost of product *X* in terms of the price or value of compound *C* (c $/lb.) and over-all yield for each reaction (Y) are written. For example,

$$\text{Unit Raw Material Cost: Reaction (1)} = \frac{8.71 - 38.6c}{Y_1}$$

$$\text{Unit Raw Material Cost: Reaction (2)} = \frac{8.37 + 38.6c}{Y_2}$$

Letting $Z = Y_2/Y_1$, the values of C and Z for equal raw material costs by reactions (1) and (2) can be plotted as a line where C is the abscissa and Z the ordinate. Similar lines can be plotted for the five other pairings possible with the four reactions. Results are shown in Figure 1. Each of the lines divides the field in two parts such that all points on one side represent conditions under which one reaction is the more economical whereas points on the other side of the line represent conditions where costs favor the other reaction. Examination of Figure 1 leads to the following observations.

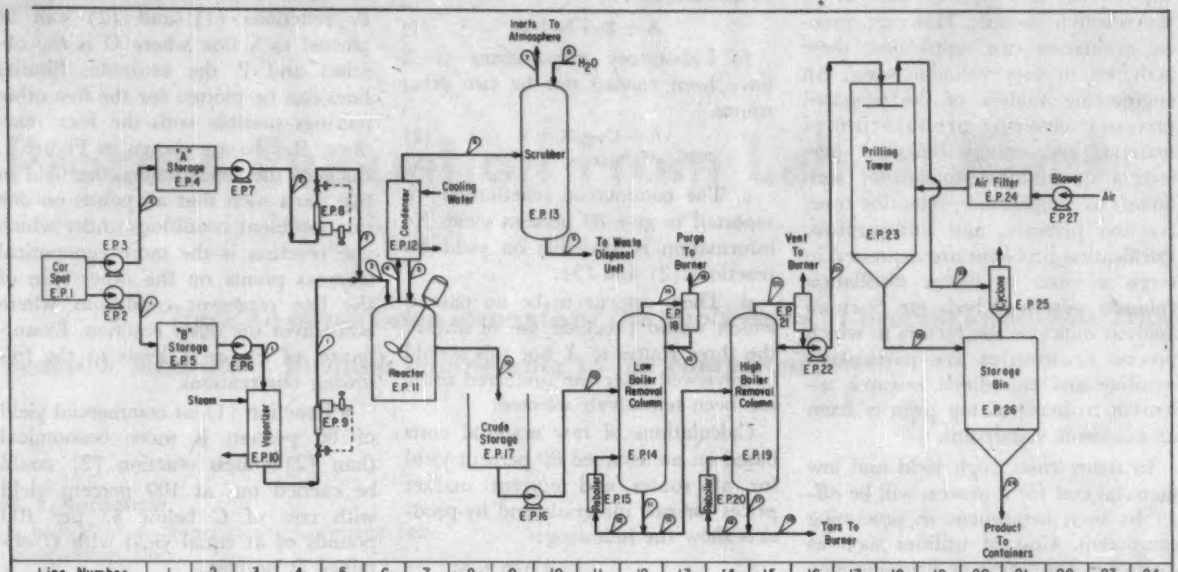
- Reaction (1) at commercial yield of 80 percent is more economical than (2) unless reaction (2) could be carried out at 100 percent yield with cost of *C* below $3 per 100 pounds or at equal yield with *C* obtained at no cost.
- Reaction (1) is more economical than (3) under all conditions where value of *C* is less than $6 per 100 pounds and is only competitive at this point if (3) gives 100 percent yield.
- Reaction (1) is more economical than (4) unless reaction (4) can be carried out at 90 percent yield with free *C* or 100 percent yield with *C* less than $2 per 100 pounds.

Reaction (3) is eliminated from further consideration as it is known that *C* can be manufactured for less than $4 per 100 pounds.

Since potential advantage of (4) over (1) is less than $100,000 per year at 100 percent yield for reaction (4) and is appreciably more complex, this route is also eliminated.

How good is route (2)? At 100 percent yield with free *C* we find a potential of $260,000 per year compared to (1) at 80 percent yield and no credit for by-product C. This is reduced to $160,000 if yield is only 90 percent and the potential is eliminated at 90 percent yield for (2) if (1) gets a $3/100 lb. credit for by-product C or if (2) must pay $3/100 lb. for *C*. The probability of (2) proving to be the better process appears to be slim, so (1) is selected for intensive study.

Initial laboratory experiments show that reaction (1) goes readily, is highly exothermic, and competes with two other reactions giving byproducts



Line Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Process Material Or Line Description																								
Physical State Of Stream																								
Flow lbs. Hour - Ave.																								
Flow lbs. Hour - Max.																								
Flow Ave. GPM or CFM/Hr																								
Flow Max. GPM or CFM Area																								
Operating Temperature C																								
Operating Pressure PSIA																								
A																								
B																								
H_2O																								
M																								
N																								

FIGURE 2—Work sheet for making energy and material balance for reaction (1). Plant is sized for 20 million pounds per year of X from A and B operating at design capacity 8,000 hours per year and product purity of 99.5 percent minimum.

M and *N*. The yield of 80 percent is confirmed from raw material *A* but only 60 percent from *B* since *M* and *N* both contain more *B* than does the desired product *X*.

At this point, an engineer with extensive experience at process evaluation, is called in to review the process. His work is to run concurrently with laboratory study of optimum conditions.

The engineer quickly reviews the raw material cost calculations for the various routes and determines that the higher than anticipated consumption of *B* for reaction (1) increases the potential for reaction (2) by $57,000 per year. This constitutes no significant change in the situation, i.e. route (1) still seems to be our best bet.

Next the engineer draws up a flow sheet (Figure 2) for plant scale production of *X* by route (1) and makes an energy balance from data in the literature and some "educated" guesses. The process appears straightforward. The reaction is rapid. The products are all liquids under reaction conditions and are completely miscible with the reactants. Reactor pressure can be held close to atmospheric and still permit removal of reaction heat by refluxing.

Excess *A*, *B*, and possible low boiling impurities should be easily removable in a single small stripping column, since *A* and *B* boil substantially below *X* and no low boiling impurities have been found in the lab work to date. A second column should suffice to separate product from the high boilers.

However, review of the properties of *M* and *N* shows that the two compounds form an azeotrope boiling 1 C. above *X*. Trouble! Engineering calculations show 60 actual plates and 20-to-1 reflux will give the desired separation.

A filtered air supply, prilling tower, cyclone, and storage facilities complete the product line but chemist and engineer have both noted that disposal of byproduct *C* (if it cannot be sold) will require waste disposal facilities. Calculations indicate these facilities will cost $500,000 to install and chemicals for waste treatment will cost $50,000 per year. Since route (2) would not need such facilities, the differential in favor of (1) appears to be shrinking.

The engineer knows management looks for 10 percent return on investment after taxes. His experience also tells him that the depreciation and maintenance on the waste disposal facilities will approximate $50,000 per year. The need for waste disposal facilities, therefore, improves the position of (2) relative to (1) by another $200,000.

The engineer now makes a flow sheet and material and energy balance for route (2). After discussion with the chemist he decides to base his work on 85 percent conversion in the reactor and recirculation to give essentially 100 percent yield from *D* with no significant byproduct forma-

tion. Cost of *C* will be assumed to be the same as manufacturing cost plus return on investment for production at the company's Darville Plant ($3.60 per 100 pounds).

The engineer proposes to dehydrate the purchased solution of raw material *D* in a column, removing pure molten *D* at the bottom for feed to the top of a sieve-plate reactor. Raw material *C* will enter the center of a second column reacting with downcoming *D*. Excess *C* will be condensed at the top and partially refluxed to hold unreacted *D* in the column. The remainder will be recirculated to the center feed point except for a small purge stream. Molten product *X* will be removed at the bottom already stripped of low boilers. A third column will vaporize *X* overhead removing high boilers which will be burned with the purge stream.

Evaluation estimates of the costs involved for routes (1) and (2) reveal the information shown in Table 1.

TABLE 1—Cost Estimates Used for Evaluating Routes 1 and 2

Route	(1)	(2)
Investment:		
Buildings	$ 150,000	$ 150,000
Process Equipment	2,090,000	2,200,000
Utilities	360,000	200,000
Waste Disposal	500,000	50,000
	$3,100,000	$2,600,000
Operating Costs:		
Raw Materials—$/yr.	$ 951,000*	$ 976,000*
Op. Labor—$/yr.	40,000	40,000
Maint. & Depre.—$/yr.	400,000	340,000
Waste Disposal—$/yr.	50,000	.....
Total Direct Op. Cost—$/yr.	$1,441,000	$1,356,000
Required Return†	620,000	520,000
Cost Plus Return	$2,061,000	$1,876,000

* Including $3.60/100 lb. C price or credit.
† Gross 20 percent of investment to give 10 percent return after Federal Income Tax of 50 percent.

Route (2) now appears to have an advantage in investment which outweighs the raw material cost penalties. The engineer requests a few scouting tests to check his assumptions on route (2). Since only three weeks has been spent on lab work on route (1) and no heavy commitments made, the engineer has little trouble convincing the chemist and management that route (2) should be scouted.

The first few experiments show only 50 percent conversion but appear to confirm the assumption of no byproducts. Compound C recovered as excess from the first reactions is used in a subsequent reaction and produces quality product at normal reaction rate.

Revision of engineering flow sheets and estimates proceeds concurrently. Cost plus return differential in favor of (2) shrinks somewhat due to the higher than anticipated recirculation rates but (2) still shows a clear-cut advantage of $150,000 per year over route (1).

Careful consideration of investment requirements for route (3) and (4) convinces the engineer that these routes have no investment advantage over (1) and (2). This is not an offhand judgment but actually involves the preparation of flow sheets and material and energy balances although these are in less detail than for (1) and (2).

At the next periodic management review, engineer and chemist present a detailed analysis of the operating cost, including raw materials, labor, utilities, maintenance, and depreciation for the four possible routes, together with evaluation-type estimates of the investments involved. This clearly shows the operating and investment cost factors which over-balance the originally-considered raw material costs. On this basis, the choice of route (2) is approved and management decision made to proceed as rapidly as possible with the development work.

The schedule is tight and achieving optimum results requires the closest cooperation. Engineering lists the information needed for sound design: physical and chemical properties of raw materials and products, liquid-vapor equilibrium data for various temperatures and pressures, reaction rates and chemical equilibrium data under various conditions, required purities, etc. Some information on these points is available from the literature but much of this is of unknown accuracy and needs at least spot-checking. The chemist and engineer agree upon a program for obtaining the necessary data and convince management to assign required additional manpower to the project.

While waiting for more accurate data, the engineer, with what data he has, examines the proposed process more carefully. Should this reaction be batch or continuous? Should water be removed from the raw material or retained through the reaction and removed from product? At what pressure should the reaction be carried out? Each of these, and numerous other questions are the subject of a careful evaluation starting with alternative flow sheets, material and energy balances and proceeding through sizing of equipment to estimates of investment and operating cost. Results of these evaluations are compared on a cost plus return basis.

The many evaluations made to aid in the selection of the proper course at each research crossroads will vary considerably in degrees of detail. It is important that all practical alternates be examined in a systematic manner which will take into account all significant factors. Consideration of raw material cost and yield alone is not enough, nor is investment by itself the proper criteria. Each decision must be made on the basis of a careful prediction of the plant scale implications of that decision in terms of raw material cost, operating cost, and investment. It is only by such an examination that research can be effectively guided to a commercially profitable end product in a high percentage of cases.

Engineering must now determine the need for a semi-works or pilot unit step in the transition from research to commercial plant. Experience shows that the need for a pilot unit is determined by specific conditions applying to an individual project. There is no general rule which can be followed.

Pilot plants may be built and operated for a number of reasons. Among these are: (1) to explore the effect of changing operating conditions, (2) to investigate such things as materials of construction, catalyst life, and recycle impurity build-up, (3) to develop new equipment and processes, (4) to convince top management that a new process or proposal is sound, and (5) to produce material for sales evaluation.

For operations involving recycle streams, whether they be new processes or the introduction of recycle in an existing process, it is extremely risky to proceed without a pilot plant. Recycle can completely upset an otherwise good process. Either a catalyst is poisoned, byproducts accumulate in the recycle, or some other undesirable effect develops. All these should be corrected in a pilot plant rather than in the commercial plant.

Experience during World War II demonstrated that operable plants for new processes can be designed without pilot plant data, but operation of these plants at 150-250 percent of design capacity also showed that the engineers are likely to build-in ex-

tremely large and expensive safety factors.

The method of attack on specific problems to be solved in the pilot unit must be decided before the design of pilot unit is started in order that facilities, instrumentation, and sampling facilities may be adequate. It is also desirable that the pilot unit design be scaled down from the envisioned commercial plant rather than scaled up from the laboratory facilities.

Any pilot unit program must be re-examined at frequent intervals to decide whether work should be continued as planned or whether the emphasis should be shifted. This requires continuous economic evaluations of the various alternatives to determine the probable cost of proceeding in the various available directions. The pilot plant work must be continually coordinated with research, economic evaluation, process design and manufacturing.

In the manufacture of a known product with an established market price and a low margin of profit, thorough pilot plant exploration of a new process is essential. With an entirely new product and a high margin of profit, pilot plant operations may be necessary only to determine the feasibility of a proposed route rather than for precise determination of process economics.

After a careful review of the principles cited, the engineer decides that a pilot unit is essential for the proposed manufacture of intermediate *X*. This decision is based upon the fact that *X* is commercially available so that cost differential is the major justification for the installation of new facilities for the production of X by a new route, and secondly that the proposed process involves a recycle stream which may cause an unpredictable build-up of impurities in the system with harmful results.

After management approval, the design and construction of pilot unit facilities are started. Design is greatly facilitated by the work already done in evaluation of the alternative processes. Engineer and chemist both have an excellent mental picture of the desired commercial facility and this is merely to be scaled down to pilot unit size. Facilities are to be sufficiently integrated to show effects of impurity build-up in the recycle streams, if this is going to occur. The pilot unit is also to supply information on suitable materials of construction both from a maintenance standpoint and product purity. Samples of pilot unit production are to be processed into final marketable material for sales evaluation.

At the end of pilot unit runs, basic design data are ready for the engineering department in sufficient detail to permit rapid completion of plant design and a construction cost estimate. Meanwhile the control division is completing the official estimates of operating costs for the proposed facility. Comparison of these official figures with the engineers evaluation estimates shows no major discrepancies and the project is then ready to be sent to the company management for authorization of the proposed expenditures.

The preceding synthetic case history of an application of process evaluation has been necessarily brief and many of the details of its application and many of the ramifications into which it leads have been omitted for the sake of simplicity. However, it gives an idea of the scope and method of operation of the process evaluation function. Process evaluation is not a panacea. It does not take the place of thorough and creative research effort. However, the organized approach to process evaluation indicated in the example is a valuable supplement to research effort, particularly where a project must be moved along on a tight time schedule and the product and process developed must meet the intense competition of today's chemical industry.

The effectiveness of process evaluation techniques will depend, to a large extent, upon the caliber and experience of the engineers doing the work. It is desirable to utilize men with ten to twenty years of broad experience in various phases of chemical industry technology. Experience should include plant operation, pilot unit design and operation, and commercial plant design work as well as trouble shooting and plant start-up assistance type of activity. A sound knowledge of basic chemical engineering fundamentals and a broad knowledge of over-all processing techniques and chemical processes is essential.

Much process evaluation work can theoretically be done within the organizational bounds of a research division and this will have the advantage of close relationships and cooperation. However, this presents two problems: (1) it is difficult within the one organization to maintain contact with the large number of processes and developments needed to keep proper perspective, and (2) close relationships with a project over a long period of time dulls the inquiring attitude necessary in this type of work. It is also desirable that the process evaluation be carried out by a man or group without vested interest in the outcome.

Basically, the justification for process evaluation lies in obtaining a process which can be operated economically and which requires a minimum of investment in facilities. This gives maximum chance of a long and profitable life for the enterprise. In addition to the resulting profits to the company, process evaluation also helps to attain a higher percentage of successful research projects with corollary advantages to individuals associated with such successful commercializations.

The addition of specialized engineering and economic skills to the research team is the essence of process evaluation. It is to such teamwork between science, engineering technology, and economics that we must look for tomorrow's optimum plants.

##

About the Author

Robert L. Buchanan received an engineering degree from Stevens Institute of Technology in 1937 and joined Consolidated Edison Co. of New York that same year. He has worked variously as a gas burning equipment installation supervisor, development engineer, power plant engineer, engineering inspector, field engineer, field group supervisor in pigments and photo products, consultant supervisor in materials handling and packaging, and basic data development. Buchannan has worked for Du Pont's Engineering department since 1941.

How Computers Aid Economic Studies

Here's a complete computer program for project estimating, evaluation, and studying the effect of process variables.

H. E. Jones and E. W. Kjellmark, Jr.
E. I. duPont de Nemours and Company, Inc., Wilmington, Del.

A MAJOR concern of industrial research management is how to concentrate research efforts onto those products and processes that will eventually yield the greatest return. Since there are usually many more ideas than can be investigated within the means of any research budget, every project must be evaluated frequently to judge its promise of future return. Many criteria are used to evaluate a research project.

1. If the project is for the development of a new product, that product must obviously have value.

2. There must be a technically feasible process.

3. The company must be well situated with respect to raw materials, technical knowledge, patents and market outlet.

4. Cost estimates must show that the product can be produced at a competitive price to yield a satisfactory return on the investment.

Accuracy and speed are essential in cost estimating for research guidance. Research is expensive, and unrealistic estimates, either too high or too low, may lead to diversion of research into unprofitable channels and deny the opportunity of developing a really profitable venture. For these reasons, a competent estimating group is necessary to assist in the guidance of any large industrial research organization.

The guidance of this group can be provided in many ways. It can estimate the effect of important variables such as yield, conversion, plant capacity, operating utility and return levels on the economics of the venture. Since a choice must often be made between alternatives, this group must also be able to provide meaningful comparisons.

All estimates are based on certain basic assumptions for process operability, yield, conversion and plant location. For any particular cost estimate, these assumptions are considered to be free from variability. However, within the framework of these assumptions, variability may be introduced from uncertainties in the estimates of equipment requirements and costs, labor, inventory factors, research expenses and others. In order to make valid comparisons of cost estimates, therefore, one must have a feeling for the reliability of the estimates and their component parts within the framework of the basic assumptions.

For example, a typical problem is to make estimates which will permit a choice between alternate process routes for the production of Product *"X."* Both routes are technically feasible. Route *A* is found to give Product *"X"* with a cost-plus-return of 55¢/lb. and Route *B* Product *"X"* with a cost-plus-return of 60¢/lb. The normal reaction would be to drop studies of Route *B*.

Calculation of the uncertainty in the cost-plus-return might lead to a somewhat different decision however. Route *A* might be 55(+10, —5)¢/lb. and Route *B* 60(+5, —10)¢/lb. Since there is clearly a wide overlap in costs even within the framework of basic assumptions, the two routes cannot be considered significantly different in cost. Therefore, the choice between the two must be based on other considerations or on new estimates from more sharply defined cost data.

In addition, it is important to know what portions of the cost such as raw materials or labor are of the greatest magnitude and how a change in their magnitude will affect the over-all economics of the process. Often it requires several recalculations and remanipulations of the base estimates to arrive at these numbers. If, however, the rolled-up-contribution of each cost element to the cost-of-sales-plus-net-return-on-investment, or as we shall call it, the cost-plus-return, has been calculated in advance, these questions can easily be answered.

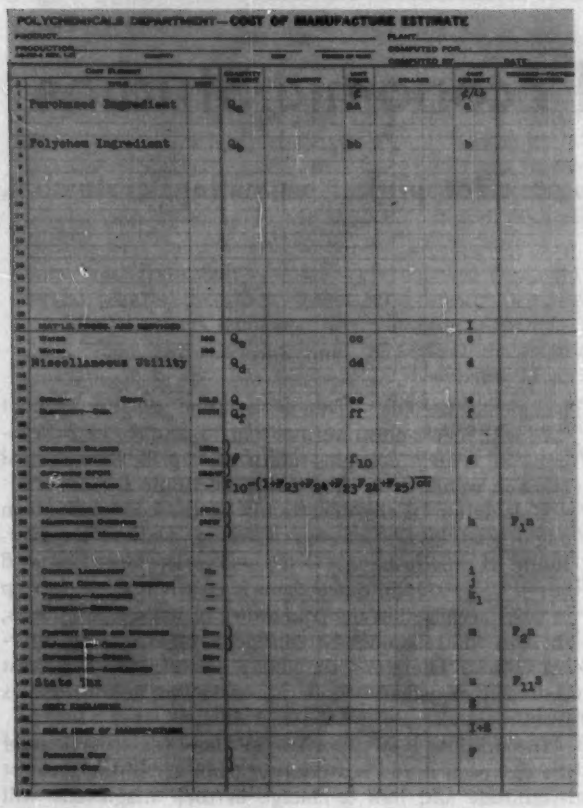
Achieving these refinements by manipulation of a base case is very time consuming, however, and it is in achieving these refinements rapidly and accurately that we have found the modern electronic computer to be of great service.

BASIC EQUATIONS FOR COST ESTIMATE

The development of such a set of equations is the first step in bringing the computer to bear on cost calculations. One of Dupont's cost estimating methods will be used to illustrate the development of the equations which express the interrelationships between the basic cost elements and the cost-plus-return.

The basic unit cost and investments (¢/lb. of product) and all of the factors which are required to calculate the cost-plus-return are tabulated on the estimating forms in Figure 1. The terms used on these forms have all been defined by Perry.[1] Individual items are denoted by lower case letters (cooling water—c); section totals by upper case letters (cost-exclusive of ingredients—E); factors determined by the estimator (such as standard inventories) by a small *f*; and standard factors determined by the departmental or company control division by capital *F* (such as depreciation rate).

Prices of raw materials, of transferred materials and of



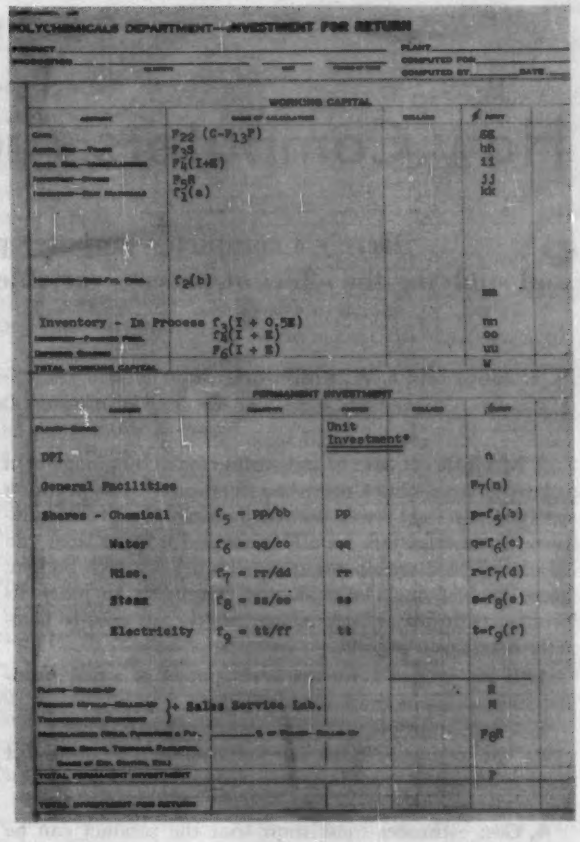


FIGURE 1—These cost estimating forms show factors and symbols used in the equations for the Cost-Plus-Return economic studies.

utilities are designated by double lower case letters aa through *ff*, and quantities by *Q* and the appropriate subscript.

Unit investments in transferred chemicals and in utilities are designated by *pp* through *tt*.

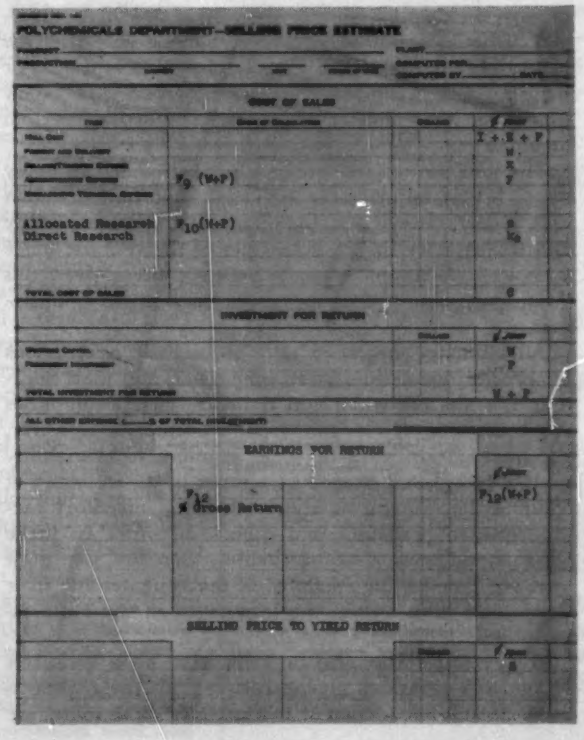
Working Capital unit costs are designated by *gg* through *kk* and *mm* through *uu*. These do not need to be determined immediately since the computer will calculate total working capital. If desired, these individual items may easily be calculated after the computer has calculated the necessary values of *C*, *P*, *S*, *I*, *E*, and *R*.

Cost-of-Sales, C, is composed of the cost of ingredients, processing costs, packaging and shipping costs, and the expenses of selling, administration, and research. This equation is derived by inspection of Figure 1:

$$C = a + b + c + d + e + f + g + i + j + k_3 + (F_1 + F_2)\,n + k_2 + w + x + F + (F_9 + F_{10})\,(P + W) + F_{11}S \qquad (1)$$

Note that maintenance as well as depreciation are functions of direct plant investment, *n*. Also, part of research is considered to be a function of total investment, $W + P$. Technical assistance, k_1, and other research directly related to the product, k_2, must be estimated by analogy to costs of other products with the advice of research management.

Working Capital, W, is made up of items shown in Figure 1. The final equation is derived by converting all



the components of working capital into primary cost elements which do not contain W. The final equation is as follows:

$$W = \frac{F_{21}S + (F_4 + F_6 + F_{22} + f_3 + f_4)(a + b) + (F_4 + F_6 + F_{22} + 0.5f_3 + f_4)[c + d + e + f + g + i + j + k_1 + (F_1 + F_2)n + F_{23}S] + f_1a + f_2b + F_3R + F_{22}[(F_9 + F_{10} - F_{12})P + w + x + F + k_2]}{1 - F_{22}(F_9 + F_{10})} \quad (2)$$

Permanent Investment, P, is composed of "rolled-up" plants investment, R; a quality, M, which includes investment in precious metals for the process, transportation equipment for the ingredients or product, and an allocated share of sales service facilities; and F_3R, equal to a fraction of "Rolled-Up" Plants to include allocated shares of real estate, etc., as shown in Figure 1.

"Rolled-up" plants include direct plant investments, n, shares of ingredients made by the department and used in the process being estimated, and allocated shares of investments in common plant site facilities such as utilities. The factors f_5 through f_9 are calculated as shown in Figure 1 by taking the ratio of the unit investment to the unit mill cost of the chemical ingredient or utility.

The equation for total permanent investment is:

$$P = (1 + F_3)[f_5b + f_6c + f_7d + f_8d + f_9d + (1 + F_7)n] + M \quad (3)$$

Cost-of-Sales Plus Net-Return-on-Investment, S, is the price for which the product must be sold in order to make a specified return, F_{12}, on the investment. The factor, F_{12}, is the gross return factor, which is multiplied by the total investment including working capital to give the required return. The equation for cost-plus-return is:

$$S = C + F_{12}(P + W) \quad (4)$$

The values of C, W, P, and S are obtained by solving the simultaneous equations 1, 2, 3, and 4.

"Rolled-Up" Contributions of each Basic Cost is developed as follows:

The cost-plus-return "S" can be expressed in terms of its basic cost elements:

$$S = \Sigma f'_{a_i}a_i + \Sigma f'_{b_j}b_j + f'_c c + f'_d d \ldots . e, f, g, i, j, k_1, n, F, M, w, x, k_2 \quad (5)$$

Where f'_a, f'_b . . . etc., are the rolled-up contributions of the respective basic cost elements to the cost-plus-return.

Equation (5) is then set equal to that equation for cost-plus-return which is obtained by solution of equations 1 through 4. All portions of the composite equation (1 through 4) which include any portion of the basic cost elements are then segregated. The summations of these individual portions make up the rolled-up contributions to the cost-plus-return.

For example, consider the contribution of an ingredient with a raw material cost of "a" cents per pound of product to the cost-plus-return. Not only is ingredient cost "a" reflected directly into the cost-plus-return through its contribution to the mill cost, but also through its contributions to working capital and hence allocated administrative and research expenses. Thus:

$$f'_a = \frac{f_a}{1 - f_8} = \frac{1 + A(Y + f_1)}{1 - f_8}$$

where A, Y, and f_8 are defined in Figure 7. In a like manner similar equations have been derived for other cost elements, such as the direct plant investment. All of these equations are tabulated in Figure 7.

In a typical example, f'_a might have a calculated value of 1.2. Therefore, if the cost of the raw material changed an amount equivalent to 2¢/lb. of product, the cost-plus-return of the product would be changed 2.4¢/lb.

Uncertainty in the Cost-Plus-Return, Mill Cost, Cost-of-Sales, Permanent Investment, and Working Capital principles has been discussed at length in the article by W. L. Gore. This principle has been applied to total cost-plus-return equations as well as those for mill cost, cost-of-sales, permanent investment, and working capital.

Equations for the uncertainties have been derived: for example, the equation for calculating "Uncertainty in the Cost-Plus-Return," e_s is as follows:

$$e_s = \frac{1.3}{(1 - f_8)^2}\left[\sum_{i=1}^{50} f'^2_{a_i}e^2_{a_i} + \sum_{i=1}^{25} f'^2_{k_i}e^2_{b_i} + \sum_{i=1}^{4}\left(f'^2_{c_i}e^2_{c_i} + f'^2_{d_1}e^2_{d_1} + \ldots\ldots \ldots d_{2_i}, d_{3_i}, e_i, f_i, g_i, i_i, j_i, k_{1_i}, n_i\right) + f'^2_F e^2_F + f'^2_M e^2_M + f'^2_w e^2_w + f'^2_{k_2}e^2_{k_2} + f'^2_x + e^2_x\right]$$

Other uncertainty equations for working capital, cost-of-sales, cost-of-manufacture, and permanent investment are available from the authors.

The probable uncertainty in the cost-plus-return "e_s"

Product: Intermediate W

	Dollars	FRACTIONS OF Q		
Installed Equipment (C.I. 212)	688,020	Best Value	Uncertainties	
Installed Equipment (C.I. 340)	Q 1,103,450	A 1.000	eA .35	—eA .25
Piping		B .50	eB .25	—eB .25
Instrumentation		D .25	eD .25	—eD .10
Miscellaneous		G .15	eG .10	—eG .05
Process Buildings	220,000	H .20	eH .10	—eH .05
Warehouse	55,000	J .05	eJ .05	—eJ .02
		K .08	eK .04	—eK .04
Outside Lines Subplant = A + —K =		L 2.23		
Engineering Costs = (X ±e$_x$) (L) =		Y .67		
Direct Plant = Q x		Z 2.90	= $3,200,000	

$$\pm e = Q\sqrt{(x+1)^2(L^2)(\pm e_A)^2 + L^2(\pm e_x)^2 + (x+1)^2/(\pm e_B)^2 + (\pm e_D)^2 + (\pm e_G)^2 + (\pm e_H)^2 + (\pm e_J)^2 + (\pm e_K)^2}$$

$+e = Q\sqrt{1.392} = 1{,}103{,}450 \times 1.180 = 1{,}302{,}000$ where $x = 0.30$, $e_x = 0.15$

$-e = Q\sqrt{0.710} = 1{,}103{,}450 \times 0.843 = 930{,}000$ $-e_x = 0.10$

FIGURE 2—From this work sheet the uncertainties for all direct plant investments can be calculated using the equations at the bottom of the table.

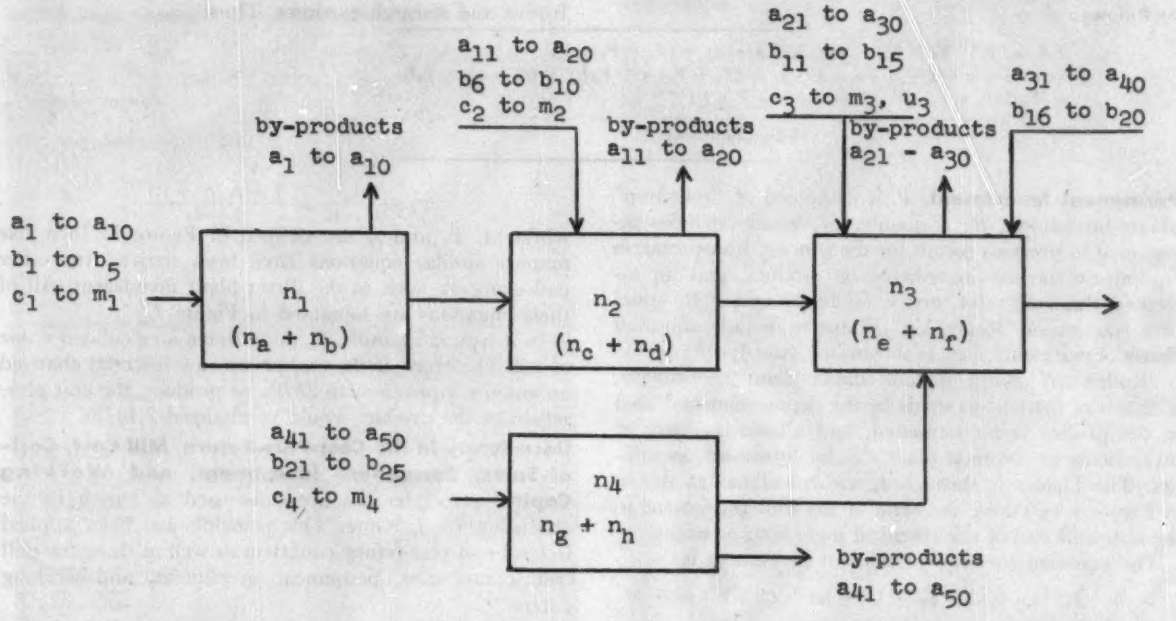


FIGURE 3—Contribution to the manufacturing cost is shown for the four processing steps adapted to the computer program.

is obtained by taking partial derivatives of the complete cost equation (5) with respect to every variable, squaring these partial derivatives, multiplying them by the squares of their respective uncertainties, summing these products and taking the square root. Thus, one gets:

$$e_s^2 = \left(\frac{\partial S}{\partial a}\right)^2 e_a^2 + \left(\frac{\partial S}{\partial b}\right) e_b^2 \ldots + \left(\frac{\partial S}{\partial f'_a}\right)^2 e_{f'_a}^2 + \ldots \quad (6)$$

Since f'_a, f'_b, etc., contain f_1 f_2 . . . . . and F_1, F_2, F_3 . . . . .

$$e_s^2 = \Sigma\,(f'_a)^2 e_a^2 + (f'_b)^2 e_b^2 + \ldots \left(\frac{\partial S}{\partial f_1}\right)^2 e_{f_1}^2 + \ldots + \left(\frac{\partial S}{\partial F_1}\right)^2 e_{F_1}^2 \ldots \quad (7)$$

Through calculation of numerous examples it has been found that e_s^2 can be approximated very closely by:

$$e_s^2 = 1.3\,[(f'_a)^2 e_a^2 + (f'_b)^2 e_b^2 + \ldots \text{ c, d, e, etc.}] \quad (8)$$

In like manner the equations for uncertainty in mill cost, cost-of-sales, and working capital have been derived and reduced to more manageable proportions by leaving out most terms which calculation showed would have little effect on the over-all uncertainty.

Development of General Equations

General equations can be developed from the basic equations for processes which have a number of process steps. It is often desirable to break a process down into two or more parallel or consecutive process steps in order to achieve greater flexibility in manipulating yields and conversions. Four such steps have been selected as a practical maximum for the computer program. This arrangement is shown in Figure 3. Accordingly, the ingredients required for a four-step process will depend on the yields in all four plants. Furthermore, the size of Plants 1 and 2 will be dictated by the yield not only of those plants but also of Plant 3. Similarly, the size of Plant 4 will be determined by yields in 3 and 4. With the arrangement shown in Figure 3, quite a variety of process layouts can be used starting with Plant 3 and adding others as required.

Estimation of Permanent Investment

The first step in computing the permanent investment is to determine the direct plant investment for each process step. This requires the preparation of a fairly detailed equipment diagram. Details of piping and of control instruments need not be shown for preliminary estimates, since these can be accounted for later as factors of installed equipment.

The size of each equipment piece is calculated by the usual engineering design formulas. The materials of construction are determined by laboratory or semiworks tests or from the literature. The installed cost of each item is then estimated. Cost curves are available in the literature[1,2,3] for many types of chemical process equipment. These curves may be supplemented by direct quotations from suppliers and from information in the company's investment records. Freight and installation costs must be included. It is important that the installed costs of all of these equipment pieces be reduced to a common construction index.

The uncertainties in the installed cost of each item are then estimated. In estimating the uncertainty in cost, allowances should be made for uncertainty in material of construction required, design uncertainties such as in heat

transfer coefficients, and normal uncertainties in the purchase price and cost of installing a given piece of equipment.

The estimated installed equipment cost for each direct plant is obtained by straight addition of the most probable values of the installed costs of the equipment pieces. The plus and minus uncertainties are calculated by taking the square roots of the sums of the squares of the respective individual uncertainties. To simplify this step, the uncertainties of minor pieces of equipment, such as small pumps and tanks, can usually be ignored, for they seldom contribute significantly to the over-all uncertainty of the estimate. These totals are then corrected to a projected value of the construction index for the year in which it is expected that the plant will be built.

Piping, instruments, and miscellaneous can be cal-

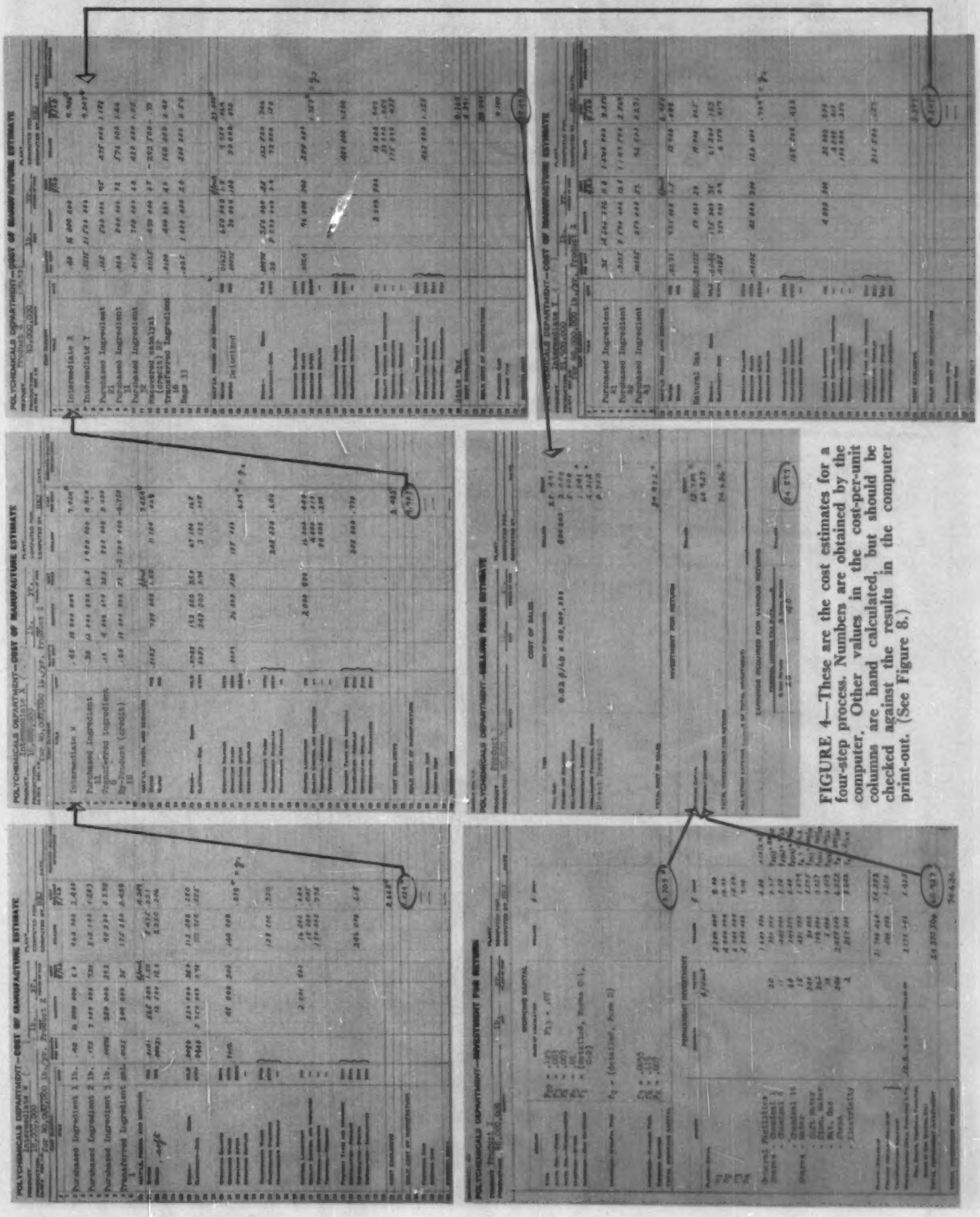
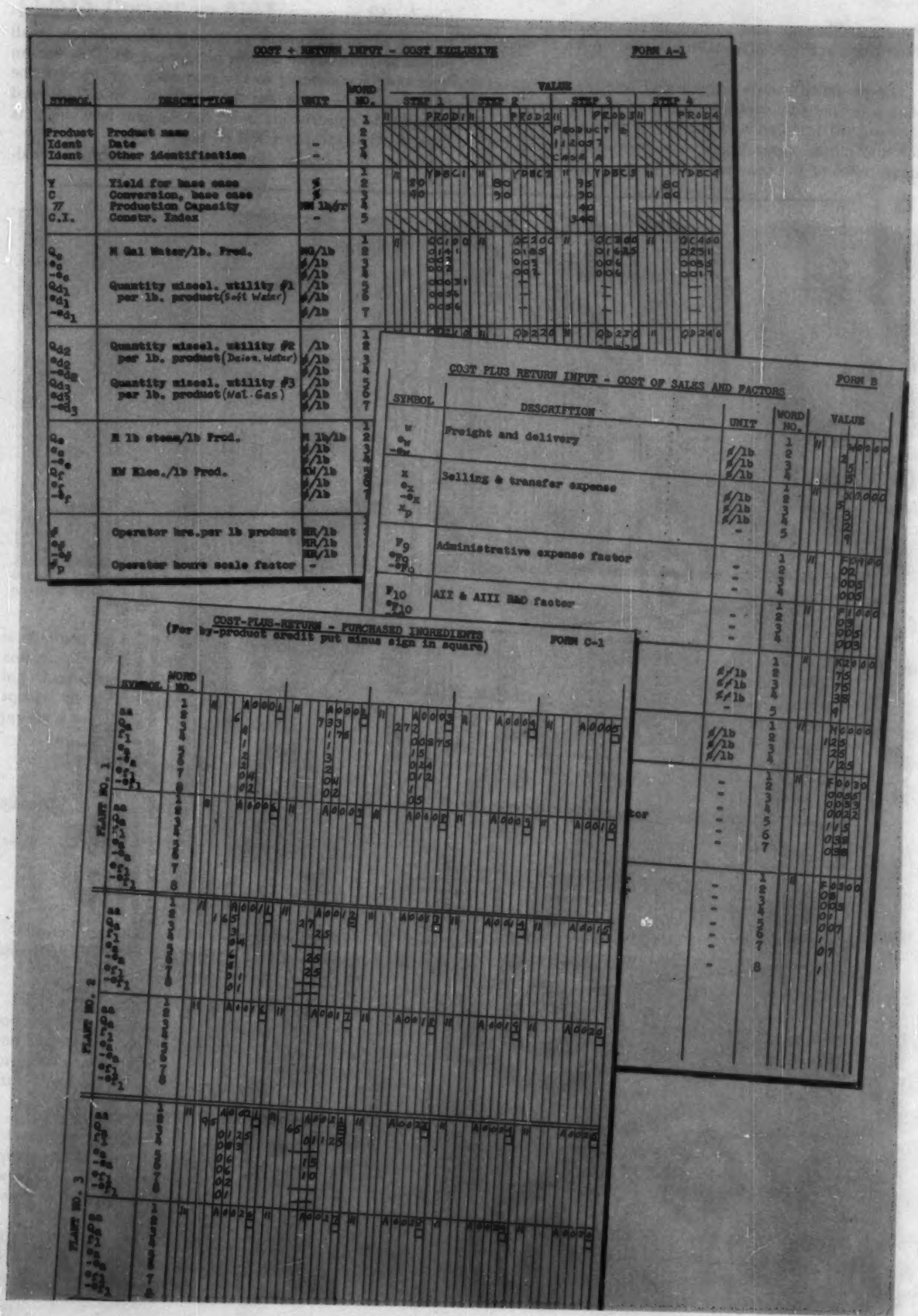


FIGURE 4—These are the cost estimates for a four-step process. Numbers are obtained by the computer. Other values in the cost-per-unit columns are hand calculated, but should be checked against the results in the computer print-out. (See Figure 8.)


COST + RETURN INPUT - COST EXCLUSIVE
FORM A-1
SYMBOL
DESCRIPTION
UNIT
WORD NO.
VALUE
STEP 1
STEP 2
STEP 3
STEP 4
COST PLUS RETURN INPUT - COST OF SALES AND FACTORS
FORM B
COST-PLUS-RETURN - PURCHASED INGREDIENTS
(For by-product credit put minus sign in square)
FORM C-1
PLANT NO. 1
PLANT NO. 2
PLANT NO. 3

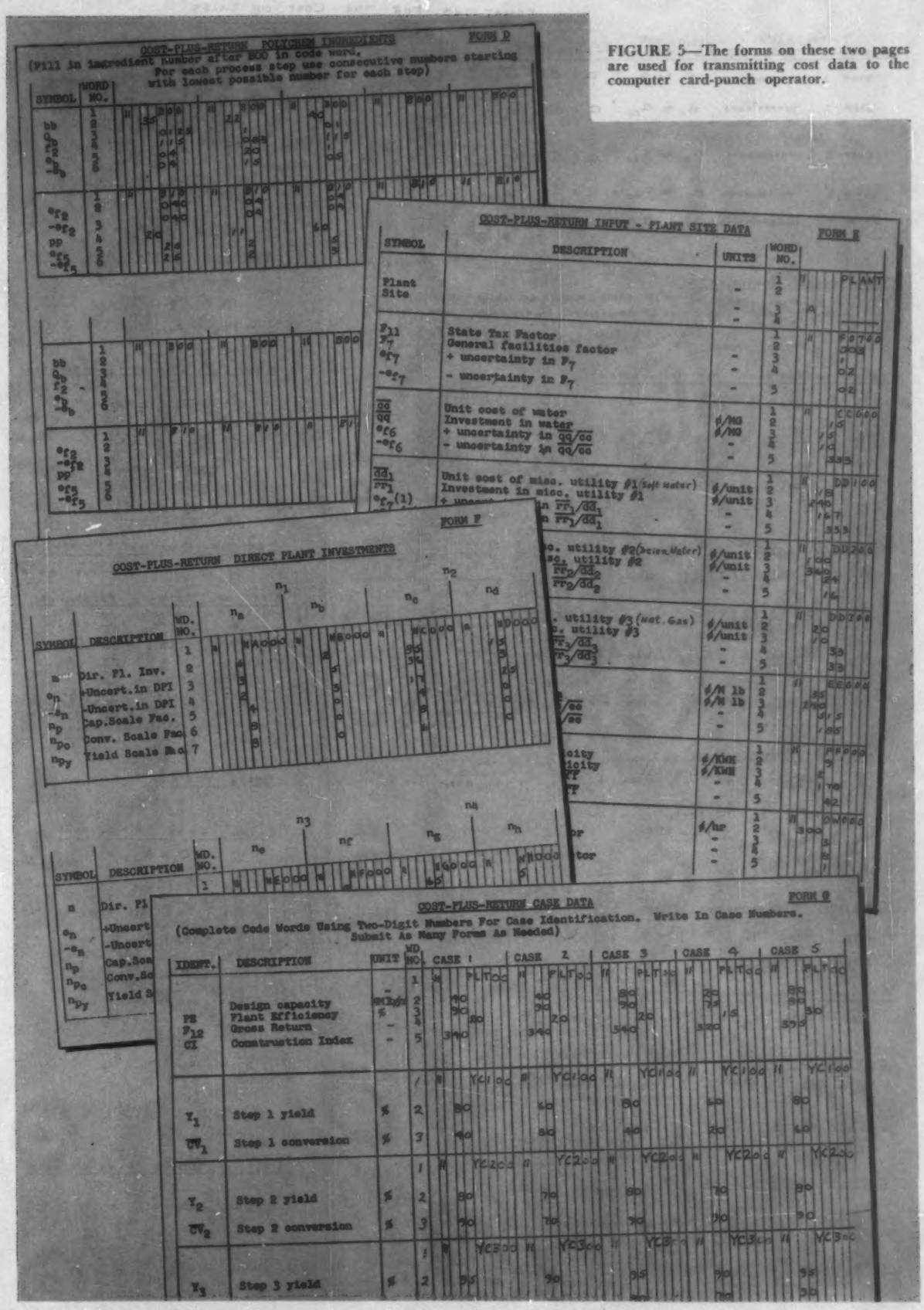

COST-PLUS-RETURN POLYCHEM INGREDIENTS
FORM D
COST-PLUS-RETURN INPUT - PLANT SITE DATA
FORM E
COST-PLUS-RETURN DIRECT PLANT INVESTMENTS
FORM F
COST-PLUS-RETURN CASE DATA
FORM G
(Complete Code Words Using Two-Digit Numbers For Case Identification. Write In Case Numbers.
Submit As Many Forms As Needed)

FIGURE 5—The forms on these two pages are used for transmitting cost data to the computer card-punch operator.

EQUATIONS FOR THE COST OF SALES

PURCHASED INGREDIENTS AND BY-PRODUCTS

STEP 1 INGREDIENTS, a_1 to a_{10}: $a = \overline{aa} \cdot Q_a^\circ \dfrac{Y_1^\circ Y_2^\circ Y_3^\circ}{Y_1 Y_2 Y_3}$

STEP 2 INGREDIENTS, a_{11} to a_{20}: $a = \overline{aa}\ Q_a^\circ \dfrac{Y_2^\circ Y_3^\circ}{Y_2 Y_3}$

STEP 3 INGREDIENTS, a_{21} to a_{30}: $a = \overline{aa}\ Q_a^\circ \dfrac{Y_3^\circ}{Y_3}$

STEP 3' INGREDIENTS, a_{31} to a_{40}: $a = \overline{aa}\ Q_a^\circ$

STEP 4 INGREDIENTS, a_{41} to a_{50}: $a = \overline{aa}\ Q_a^\circ \dfrac{Y_3^\circ Y_4^\circ}{Y_3 Y_4}$

TRANSFERRED INGREDIENTS

(EQUATIONS ARE OF THE SAME FORM AS ABOVE EXCEPT THAT THERE ARE ONLY FIVE TRANSFERRED INGREDIENTS PER STEP)

EG:

STEP 1 TRANS. INGRED, b_1 to b_5: $b = \overline{bb} \cdot Q_b^\circ \dfrac{Y_1^\circ Y_2^\circ Y_3^\circ}{Y_1 Y_2 Y_3}$

TOTAL INGREDIENTS FOR EACH STEP

$$I_1 = \sum_{i=1}^{10} a_i + \sum_{i=1}^{5} b_i$$

$$I_2 = \sum_{i=11}^{20} a_i + \sum_{i=6}^{10} b_i + I_1 + E_1$$

$$I_3 = \sum_{i=21}^{30} a_i + \sum_{i=11}^{15} b_i + I_2 + I_4 + E_2 + E_4$$

$$I_4 = \sum_{i=41}^{50} a_i + \sum_{i=21}^{25} b_i$$

COST OF WATER

$C_1 = \overline{cc}_1 Q_{c_1}^\circ \$(YC_v)_1$, where $\$(YC_v)_1 = \dfrac{Y_1^\circ Y_2^\circ Y_3^\circ C_{v_1}^\circ C_{v_2}^\circ C_{v_3}^\circ}{Y_1 Y_2 Y_3 C_{v_1} C_{v_2} C_{v_3}}$

$C_2 = \overline{cc}_2 Q_{c_2}^\circ \$(YC_v)_2$, where $\$(YC_v)_2 = \dfrac{Y_2^\circ Y_3^\circ C_{v_2}^\circ C_{v_3}^\circ}{Y_2 Y_3 C_{v_2} C_{v_3}}$

$C_3 = \overline{cc}_3 Q_{c_3}^\circ \$(YC_v)_3$, where $\$(YC_v)_3 = \dfrac{Y_3^\circ C_{v_3}^\circ}{Y_3 C_{v_3}}$

$C_4 = \overline{cc}_4 Q_{c_4}^\circ \$(YC_v)_4$, where $\$(YC_v)_4 = \dfrac{Y_3^\circ Y_4^\circ C_{v_3}^\circ C_{v_4}^\circ}{Y_3 Y_4 C_{v_3} C_{v_4}}$

COST OF MISCELLANEOUS UTILITY # 1

$d_{1(1)} = \overline{dd}_{1(1)} Q_{d_{1(1)}}^\circ \$(YC_v)_1$, where $\$(YC_v)_1$ is as above for "C"

$d_{1(2)} = \overline{dd}_{1(2)} Q_{d_{1(2)}}^\circ \$(YC_v)_2$ .....

$d_{1(3)} = \overline{dd}_{1(3)} Q_{d_{1(3)}}^\circ \$(YC_v)_3$ .....

$d_{1(4)} = \overline{dd}_{1(4)} Q_{d_{1(4)}}^\circ \$(YC_v)_4$ .....

COST OF MISCELLANEOUS UTILITY # 2

$d_{2(1)} = \overline{dd}_{2(1)} Q_{d_{2(1)}}^\circ \$(YC_v)_1$, ... and so forth for steps 1 through 4

COST OF MISCELLANEOUS UTILITY # 3

$d_{3(1)} = \overline{dd}_{3(1)} Q_{d_{3(1)}}^\circ \$(YC_v)_1$, and so forth

COST OF STEAM

$e_1 = \overline{ee}_1 Q_{e_1}^\circ \$(YC_v)_1$, etc. for steps 1 through 4

COST OF ELECTRICITY

$f_1 = \overline{ff}_1 Q_{f_1}^\circ \$(YC_v)_1$, etc. for steps 1 through 4

COST OF MAINTENANCE

$h_1 = F_{1(1)} n_1$

$h_2 = F_{1(2)} n_2$

$h_3 = F_{1(3)} n_3$

$h_4 = F_{1(4)} n_4$

COST OF OPERATING WAGES

$$g_1 = \frac{\#_1 S_{10}}{P.E.} \left(\frac{\pi^\circ Y_1^\circ Y_2^\circ Y_3^\circ}{\pi Y_1 Y_2 Y_3}\right)^{g_{1p}}$$

$$g_2 = \frac{\#_2 S_{10}}{P.E.} \left(\frac{\pi^\circ Y_2^\circ Y_3^\circ}{\pi Y_2 Y_3}\right)^{g_{2p}}$$

$$g_3 = \frac{\#_3 S_{10}}{P.E.} \left(\frac{\pi^\circ}{\pi}\right)^{g_{3p}}$$

$$g_4 = \frac{\#_4 S_{10}}{P.E.} \left(\frac{\pi^\circ Y_3^\circ}{\pi Y_3}\right)^{g_{4p}}$$

$S_{10} = (1 + F_{23} + F_{24} + F_{23} F_{24}$

COST OF TAXES AND DEPREC

$m_1 = F_{2(1)} n_1$

$m_2 = F_{2(2)} n_2$

$m_3 = F_{2(3)} n_3$

$m_4 = F_{2(4)} n_4$

COST OF CONTROL LABORATOR

$$i_1 = \frac{i_1^\circ}{P.E.} \left(\frac{\pi^\circ Y_1^\circ Y_2^\circ Y_3^\circ}{\pi Y_1 Y_2 Y_3}\right)^{i_p}$$

$$i_2 = \frac{i_2^\circ}{P.E.} \left(\frac{\pi^\circ Y_2^\circ Y_3^\circ}{\pi Y_2 Y_3}\right)^{i_p}$$

$$i_3 = \frac{i_3^\circ}{P.E.} \left(\frac{\pi^\circ}{\pi}\right)^{i_p}$$

$$i_4 = \frac{i_4^\circ}{P.E.} \left(\frac{\pi^\circ Y_3^\circ}{\pi Y_3}\right)^{i_p}$$

COST OF QUALITY CONTROL

j_1 = SAME EQUATIONS AS P

COST OF TECHNICAL ASSISTANCE

$$k_{1(1)} = \frac{k_{1(1)}^\circ}{P.E.} \left(\frac{\pi^\circ}{\pi}\right)^{k_{1p}}$$

$$k_{1(2)} = \frac{k_{1(2)}^\circ}{P.E.} \left(\frac{\pi^\circ}{\pi}\right)^{k_{1p}}$$

$$k_{1(3)} = \frac{k_{1(3)}^\circ}{P.E.} \left(\frac{\pi^\circ}{\pi}\right)^{k_{1p}}$$

$$k_{1(4)} = \frac{k_{1(4)}^\circ}{P.E.} \left(\frac{\pi^\circ}{\pi}\right)^{k_{1p}}$$

STATE TAX

$u_3 = F_{11} S$

TOTAL COST EXCLUSIVE

$E_1 = C_1 + d_{1(1)} + d_{2(1)} + d_{3(1)}$

$E_2 = C_2 + d_{1(2)} + d_{2(2)} + d_{3(2)} +$

$E_3 = C_3 + d_{1(3)} + d_{3(3)}$ .....

$E_4 = C_4 + d_{1(4)} +$ .....

TOTAL COST OF SALES

w = a constant

$$\nu = \frac{\nu^\circ}{PE} \left(\frac{\pi^\circ}{\pi}\right)^{\nu_p}$$

$$k_2 = \frac{k_2^\circ}{PE} \left(\frac{\pi^\circ}{\pi}\right)^{k_{2p}}$$

$$C = \sum_{i=1}^{50} a_i + \sum_{i=1}^{25} b_i + \sum_{i=1}^{4} E_i$$

COST OF SALES PLUS GROSS R

$$S = \sum_{i=1}^{50} a_i + \sum_{i=1}^{25} b_i + \sum_{i=1}^{4} E_i$$

FIGURE 6—These are the basic equations for cost of sales and permanent investment.

EQUATIONS FOR PERMANENT INVESTMENT

AND SALARIES

DIRECT PLANT INVESTMENT

$$n_1 = n_a + n_b$$
$$n_2 = n_c + n_d$$
$$n_3 = n_e + n_f$$
$$n_4 = n_g + n_h$$

$$\sum_{i=1}^{4} n_i = n_1 + n_2 + n_3 + n_4$$

$$n_a = \frac{n_a^\circ}{P.E.}\left(\frac{\pi^\circ Y_3^\circ Y_2^\circ}{\pi Y_3 Y_2}\right)^{n_{P\pi a}}\left(\frac{C_{v_1}^\circ}{C_{v_1}}\right)^{n_{PC_{v_1}a}}\left(\frac{Y_1^\circ}{Y_1}\right)^{n_{PYa}}\left(\frac{CI}{CI^\circ}\right)$$

$$n_b = \frac{n_b^\circ}{P.E.}\left(\frac{\pi^\circ Y_3^\circ Y_2^\circ}{\pi Y_3 Y_2}\right)^{n_{P\pi b}}\left(\frac{C_{v_1}^\circ}{C_{v_1}}\right)^{n_{PC_{v_1}b}}\left(\frac{Y_1^\circ}{Y_1}\right)^{n_{PYb}}\left(\frac{CI}{CI^\circ}\right)$$

$$n_c = \frac{n_c^\circ}{P.E.}\left(\frac{\pi^\circ Y_3^\circ}{\pi Y_3}\right)^{n_{P\pi c}}\left(\frac{C_{v_2}^\circ}{C_{v_2}}\right)^{n_{PC_{v_2}c}}\left(\frac{Y_2^\circ}{Y_2}\right)^{n_{PYc}}\left(\frac{CI}{CI^\circ}\right)$$

$$n_d = \frac{n_d^\circ}{P.E.}\left(\frac{\pi^\circ Y_2^\circ}{\pi Y_2}\right)^{n_{P\pi d}}\left(\frac{C_{v_2}^\circ}{C_{v_2}}\right)^{n_{PC_{v_2}d}}\left(\frac{Y_2^\circ}{Y_2}\right)^{n_{PYd}}\left(\frac{CI}{CI^\circ}\right)$$

$$n_e = \frac{n_e^\circ}{P.E.}\left(\frac{\pi^\circ}{\pi}\right)^{n_{P\pi e}}\left(\frac{C_{v_3}^\circ}{C_{v_3}}\right)^{n_{PC_{v_3}e}}\left(\frac{Y_3^\circ}{Y_3}\right)^{n_{PYe}}\left(\frac{CI}{CI^\circ}\right)$$

$$n_f = \frac{n_f^\circ}{P.E.}\left(\frac{\pi^\circ}{\pi}\right)^{n_{P\pi f}}\left(\frac{C_{v_3}^\circ}{C_{v_3}}\right)^{n_{PC_{v_3}f}}\left(\frac{Y_3^\circ}{Y_3}\right)^{n_{PYf}}\left(\frac{CI}{CI^\circ}\right)$$

$$n_g = \frac{n_g^\circ}{P.E.}\left(\frac{\pi^\circ Y_4^\circ}{\pi Y_4}\right)^{n_{P\pi g}}\left(\frac{C_{v_4}^\circ}{C_{v_4}}\right)^{n_{PC_{v_4}g}}\left(\frac{Y_4^\circ}{Y_4}\right)^{n_{PYg}}\left(\frac{CI}{CI^\circ}\right)$$

$$n_h = \frac{n_h^\circ}{P.E.}\left(\frac{\pi^\circ Y_4^\circ}{\pi Y_4}\right)^{n_{P\pi h}}\left(\frac{C_{v_4}^\circ}{C_{v_4}}\right)^{n_{PC_{v_4}h}}\left(\frac{Y_4^\circ}{Y_4}\right)^{n_{PYh}}\left(\frac{CI}{CI^\circ}\right)$$

ROLLED-UP INVESTMENT

$$R = (1+F_7)\sum_{i=1}^{4} n_i + \sum_{i=1}^{29} S_{5_i} h_i + S_6 \sum_{i=1}^{4} c_i + \sum_{j=1}^{3}\sum_{i=1}^{4} S_{7_i} d_{j_i} + S_8 \sum_{i=1}^{4} e_i + S_9 \sum_{i=1}^{4} b_i$$

PERMANENT INVESTMENT

$$P = (1+F_8)R + M$$

$$M = \frac{M^\circ}{P.E.}\cdot\frac{\pi^\circ}{\pi}$$

WORKING CAPITAL

$$W = F_{22}(C - F_{13}P) + F_3 S + (S_4 + F_4 + F_6)(I_3 + E_3) + F_5 R + \sum_{i=1}^{20} f_{1_i} a_i + \sum_{i=1}^{29} S_{2_i} b_i + S_3\left[\sum_{i=1}^{20} a_i + \sum_{i=1}^{29} b_i + \frac{1}{2}\sum_{i=1}^{4} E_i\right]$$

SYMBOLS USED IN THIS TABLE

Y_i°, Y_i = Yields for base case and variation of same one respectively.

$C_{v_i}^\circ$, C_{v_i} = Conversions for base case ....

π°, π = Plant capacities for .....

P.E. = Per cent of operating capacity

g_p, i_p, n_p = Scale factors

$n_{P\pi b}$ = Scale factor for "b" direct plant. Effect of plant capacity

$n_{PC_{v_1}b}$, n_{PYb} = Scale factors for "b" direct plant. Effects of conversion and yield respectively.

culated as percentages of installed equipment cost. Factors for these items are based on previous company experience. A range of values is given in Table 1.

TABLE 1
Factors as Percentages of Installed Equipment

	Instruments	Piping	Miscellaneous	Outside Lines
Solids System	4–20	10–40	4–20	0–10
Fluids System	10–40	25–75	2–10	4–15

To these must be added an estimate for the process building and for the warehouse. Text books are available to assist in estimating building requirements and costs.[4]

The total of all items thus far gives the cost of subplant manufacturing. To this must be added another 30 percent to 50 percent of the total to cover the cost of plant site preparation and engineering services.

All of these components of direct plant investment are listed on a form such as that shown in Figure 2. The uncertainties are calculated by the equation shown. An example of the calculation of the direct plant investment and the uncertainties for a fluid process is given in Figure 2.

In scaling a plant to large size many equipment pieces can simply be made that much larger, but often it becomes necessary, where equipment pieces have already reached their maximum practical size, to add duplicate units. Different scale exponents will be required to handle these two situations. Therefore, each direct plant has been divided into two parts and each part designated by lowercase letter subscripts as shown in Figure 3. The proper exponent can then be applied to the appropriate portion of each direct plant.

Estimation of Cost-of-Sales

Ingredients. Raw materials requirements are determined by the yields assumed in the base case and the material balance throughout the plant. Costs may be obtained from published lists, the company purchasing agent, or by inquiry from a supplier. Freight charges should be included.

Purchased ingredients for the first step in the process are designated a_1 through a_{10}, second step ingredients a_{11} through a_{20}, third step ingredients a_{21} through a_{30}. Ingredients which are added at the end of the third step and which, therefore, do not suffer yield losses, are designated a_{31} through a_{40}. Ingredients for an intermediate made in Plant 4 (see Figure 3) are designated a_{41} through a_{50}. In each case a_i equals the dollars ingredient cost per annual pound of final product. Uncertainties in ingredient costs, $+e_{a_i}$ and $-e_{a_i}$, must also be estimated on the basis of historical variations in the market price or uncertainty in grade required. By-products are also designated with letter a's using negative values.

Transferred ingredients are handled in the same way using designations b_1 to b_5, b_6 to b_{10}, b_{11} to b_{15}, b_{16} to b_{20}, and b_{21} to b_{25} as shown in Figure 3. In each case b_i equals the transfer cost of the transferred ingredient (including any transportation) per annual pound of final product. Uncertainties, $+e_{b_i}$ and $-e_{b_i}$, are estimated on the basis of historical fluctuations in mill cost or of changes anticipated on the basis of expansion, improved process, etc.

The inventory factors for raw materials, f_{i_1}, in fractional years are developed either from standard inventory factors maintained by the company for the particular ingredients or by analogy to comparable ingredients for which factors are available or from considerations of storage time, delivery time, and size of purchase lot. Uncertainties in these factors, e_{f_1}, will probably be small if standard inventory factors are used and large in the other cases.

Charges for utilities are based on requirements determined from flowsheets for the base case. To these must be added allowances for heat losses and building heating needs. Uncertainities in the cost of the utility per annual pound of product are based primarily on variations in the mill cost of the utility. These variations are usually small for a given, well-established plant.

Operating expense, g, is calculated by the computer from the operating man-hours requirement, wage rate, and factors for salaries, overhead, and supplies based on direct operating wages. The symbol, #, refers to the number of operating man-hours per annual pound of product. Quantity OW is the anticipated average operating wage. Factor f_{10} is an adjusted wage rate which includes allowances for salaries, overhead, and supplies. Uncertainties in g arise principally from possible misestimation of the man-hours required.

Maintenance costs are taken as a factor of the direct plant investment. The factor is selected by analogy to a similar existing plant, and the uncertainties in F_1 are obtained from the observed spread in these factors. If factors are not obtaintable, the factor h can be found by detailed estimation of the number of maintenance men required and the amount of overhead and supplies expected.

Control Laboratory expenses, i, are usually based on the number of analysts required, times a factor to cover salaries and all operating costs of the laboratory. This factor may range from $6 to $12 per analytical manhour.

Quality Control, j, and Technical Assistance, k_1, should be estimated for each case and will depend on the complexity of the process. Rather wide uncertainty limits may have to be placed on these items.

Property Taxes and Depreciation are combined in factor F_2 as a composite function of direct plant investment. The tax rate will vary with the location, and the depreciation rate may depend on the rate of obsolescence or wear and tear on the equipment. The uncertainties should be selected accordingly.

Freight and delivery, w, is estimated on a dollar-per-unit-of-product basis. Estimates must be made for each case. The company's traffic department or a carrier may be consulted.

Selling or Transfer Expense, x, must also be estimated for each case. The sales division may be of help here.

Administrative Expense and certain **research expenses** are factored from total investment. Factors have

ROLLED-UP CONTRIBUTIONS TO THE COST-PLUS-RETURN

ROLLED-UP CONTRIBUTIONS TO THE COST-PLUS RETURN ARE DEFINED AS:

$$f'_a \;,\; f'_b \;,\; f'_c \;,\; f'_{d_1} \;,\; f'_{d_2} \;,\; f'_{d_3} \;,\; f'_e \;\ldots\ldots\; f, g, i, j, k_1, n, F, M, w, k_2, t$$

and f'_a, f'_b .... etc. $= \dfrac{f_a}{1-f_3}$, $\dfrac{f_b}{1-f_3}$ ..... etc.

where:

$$f_3 = F_{11} + F_{12}(F_3 + F_{11}H)(1 + F_{22}GD) + GD(F_3 + F_{11}H)$$

and

$$f_{a_i}\ (\text{ingredients}) = 1 + YA + f_{1_i}A \qquad i = 1 \text{ to } 50$$

$$f_{b_i}\ (\text{transferred ingredients}) = 1 + YA + f_{2_i}A + f_{5_i}(F_5A + (1+F_8)V) \qquad i = 1 \text{ to } 25$$

$$f_{c\,,d_1\,,d_2\,,d_3\,,e\,,f} = 1 + HA + f_{6,7,7_1,7_2,7_3,8,9}(F_5A + (1+F_8)V)$$

$$f_{g\,,i\,,j\,,k_1} = 1 + HA$$

$$f_{w\,,t\,,k_2,F} = 1 + F_{22}A$$

$$f_m = V$$

$$f_{n_i} = F_{1_i} + F_{2_i} + A\left[H(F_{1_i} + F_{2_i}) + F_5(1+F_7)\right] + (1+F_8)(1+F_7)V \qquad i = 1 \text{ to } a$$

WHERE:

$$A = F_{12} + (F_9 + F_{10})(1 + F_{22}F_{12})D$$
$$B = (F_9 + F_{10})(1 + F_8)$$
$$D = \left[1 - F_{22}(F_9 + F_{10})\right]^{-1}$$
$$G = F_9 + F_{10}$$
$$H = F_4 + 0.5f_3 + f_4 + F_6 + F_{22}$$
$$T = 1 + F_{22}F_{12}$$
$$V = (F_9 + F_{10})(1 + F_{22}F_{12}) + F_{12} + (F_9 + F_8)^2(1 + F_{22}F_{12}) - F_{13}F_{12}\left[F_{12} + (F_9 + F_{10})(1 + F_{22}F_{12})D\right]$$
$$Y = F_4 + f_3 + f_4 + F_6 + F_{22}$$
$$Z = F_{22}(F_9 + F_{10} - F_{13})(1 + F_8) + F_5$$

FIGURE 7—Equations for rolled-up contributions to cost-plus-return.

been developed for this purpose. Others may factor these expenses from gross sales or earnings. In such cases, certain of the equations would have to be revised.

Estimation of Working Capital

Working capital can be set up for solution by the computer very quickly provided a control division in the company has already calculated the necessary factors from company experience. For proposed new products standard factors are applied and suitable inventory "*f*" factors can be obtained by analogy to existing products.

The computer program is arranged to give

$$\sum_{i=1}^{50} f1_i\, a_i \quad \text{and} \quad \sum_{i=1}^{25} f2_i\, b_i$$

Other components of the working capital are also summarized. The total value of *W* is then shown in the print out.

Use of Scale Factors

The use of scale factors is a great aid in determining the effect of scale on the process costs, since the computer upon instruction can compute these costs and the cost-plus-return for any scale of operation either greater or less than the base case. The use of these scale factors in a computer program can be illustrated by hand manipulation of any of the equations in which scale factors are shown in Figure. 6.

For example, it has been found[5] that a scale factor (or exponent) of 0.4 applies very well to plant investment where

$$n_{new} = n^o\left(\frac{\pi^o}{\pi_{new}}\right)^{.4}$$

$$n_{new} = 50¢/\text{lb.}\left(\frac{40{,}000{,}000\ \text{lb./yr.}}{100{,}000{,}000\ \text{lb./yr.}}\right)^{.4}$$

$$= 50\,(.4)^{.4} = 50 \times .693 = 34.7¢/\text{lb.}$$

A scale factor of 0.8 has been found appropriate for operating expenses[6]. Factors in the range of 0.8 to 0.9 may be found applicable to research, control laboratory, and quality control costs. To take another case, notice what

happens to operating expense when the scale of operation is reduced from 10,000,000 lb./yr. in the base case to 5,000,000 lb./yr. and the yield is decreased from 80 percent to 60 percent. For a base case let

$$g_2 = \frac{\#f_{50}}{PE} = \frac{(.0012)(690)}{1.00} = 0.828¢/lb.$$

Substituting the above values into the equation for g shown in Figure 6:

$$g_2 = (0.828)\left(\frac{10}{5} \cdot \frac{80}{60}\right)^{0.8} = (0.828)(2.19) = 1.81¢/lb.$$

Since the scale factor may be inaccurate due to lack of experience and since the factor itself may change when the plant becomes so large that further expansion is practical only by multiplication of units, meaningful results may not be obtained if the computer is used to extrapolate too far on either side of the base case.

Computer Input Forms

All of the information required for the base case of a cost-plus-return estimate is contained on the work sheets shown in Figure 4. It is now necessary to transmit this information to the computer. To achieve this, a set of data input forms have been prepared as shown in Figure 5.

Form A-1 (Figure 5) contains product identification and the conditions of yield, conversion, construction index, and production scale for the base case.

Form B is for cost-of-sales items and working capital factors.

Information pertaining to purchased ingredients is entered on Forms C-1.

Information on transferred ingredients is transmitted in Form D.

Form E is for cost data pertaining to a particular plant site.

This system has two advantages: (1) the estimator is saved the time and effort of looking up these pieces of information for each estimate and for estimating the required uncertainties, and (2) for a given plant site and year the same plant costs will go into all estimates, permitting closer comparisons among estimates.

Values for base-case, direct-plant investments, uncertainties, and scale factors are entered in Form F. Values for n and $\pm e_n$ are all in cents per pound of final product.

With Form G the estimator can ask for variations of the base case in which the yields, conversions, design capacity, etc., are varied at will to cover the range of interest. As many G forms may be filled out as are needed.

Sample Solution. In order to illustrate the application of the equations developed here to the calculation of the cost-plus-return by a computer a synthetic cost estimate is shown in Figures 4, 5, and 8 in which arbitrary unit costs and factors were employed. The cost elements for calculating the cost-plus-return for a four step process as well as the hand solution of the base case are detailed in Figure 4. The computer input data including the basic

Computer Print-Out for the Base Case

COST PLUS RETURN

PRODUCT 2 112 57	CASE BASE		PROD MM		40.001
PLANT A			GROSS RETURN		0.201
PE	100.001	CI	340.001		
Yield	80.001	80.001	95.001	80.001	
Conv.	40.001	90.001	90.001	100.001	
F PRIME	PLT 3	END 3	PLT 1	PLT 2	PLT 4
FA	1.104	1.115	1.109	1.093	1.088
FA	1.083	1.115	1.109	1.085	1.091
FA	.....	1.104	1.122	.....	1.127
FB	.....	1.538	1.275	1.246	.....
FC	3.918	.....	3.918	3.918	3.918
FD	4.863	.....	4.863	4.863	4.863
FD	2.103	.....	2.103	2.103	2.103
FD	1.224	.....	1.224	1.224	1.224
FE	3.027	.....	3.027	3.027	3.027
FF	1.713	.....	1.713	1.713	1.713
GIJK1	1.082	.....	1.082	1.082	1.082
WXK2	1.051	.....	1.051	1.051	1.051
M	0.255	.....	0.255	0.255	0.255
N	0.482	.....	0 439	0.461	0 461
A	1.188	1.441	2.401	4.951	3.851
A	— 0.731	1.051	1.283 —	6.751	2.869
A	.....	0 501	0.238	.....	0.231
Sum A	3.446	.....	3.921 —	1.801	6,951
I & E	9.906	.....	.....	7.024	.....
I & E	9.247	.....	.....	.....	.....
B 1	.....	0.401	0.438	2.201	.....
Sum B	19,554	0.401	0.438	9.224	.....
INGR	23,001	.....	4,358	7.424	6.951
Plus	2.841	.....	0.364	2.671	0.501
Minus	2.676	.....	0.286	2.585	0.501
Water	0.024	.....	0.021	0.028	0.035
Misc. 1	.....	.....	0.006	.....	.....
Misc. 2	0.075	.....	.....	.....	.....
Misc. 3	.....	.....	.....	.....	0.025
Steam	0.306	.....	0.281	0.168	0.153
Elec.	0.181	.....	0.085	0.008	0.017
Oper.	1.757	.....	0.878	0.659	0.769
Maint.	1.201	.....	0.321	0.601	0.421
Cont.	0.041	.....	0.041	0.041	0.081
Qual.	0.051	.....	0.045	0.011	0.011
Tech.	0.438	.....	0.375	0.201	0.251
Depr.	1.155	.....	0.616	0.771	0.539
S-Tax	0.165	.....	.....	.....	.....
P. & S.	0.101	.....	.....	.....	.....
C. E.	5.491	.....	2.666	2.482	2.297
Plus	0.753	.....	0.587	0.696	0.371
Minus	0.913	.....	0.409	0.341	0.244
E. & I.	28.491	.....	7.024	9.906	9.247
Plus	2.939	.....	0.691	2.759	0.623
Minus	2.827	.....	0.499	2.607	0.557
TOTAL PLANTS:					
Sum A	12.517	.....	.....	.....	.....
Sum B	3.038	.....	.....	.....	.....
Total Ingr.	.....	15.556	.....	.....	.....
Uncertainty	.....	.....	2.665 —	2.611	.....
Water	0.108	.....	.....	.....	.....
Misc. 1	0.006	.....	.....	.....	.....
Misc. 2	0.075	.....	.....	.....	.....
Misc. 3	0.025	.....	.....	.....	.....
Steam	0.908	.....	.....	.....	.....
Elec.	0.280	.....	.....	.....	.....
Oper.	4.063	.....	.....	.....	.....
Maint.	2.541	.....	.....	.....	.....
Cont.	0.201	.....	.....	.....	.....
Qual.	0.115	.....	.....	.....	.....
Tech.	1.263	.....	.....	.....	.....
Depr.	3.081	.....	.....	.....	.....
S-Tax	0.165	.....	.....	.....	.....
P. & S.	0.101	.....	.....	.....	.....
C. E.	.....	10.638	.....	.....	.....
Uncertainty	.....	.....	1.238 —	1.084	.....
Cost Manufactr	.....	28,491	.....	.....	.....
Uncertainty	.....	.....	2.9389 —	2.8269	.....
Mill Cost	28,491	.....	.....	.....	.....
Freight & Del.	2.001	.....	.....	.....	.....
Selling & Tran.	5,001	.....	.....	.....	.....
Admin.	1.493	.....	.....	.....	.....
Alloc. Res.	2.239	.....	.....	.....	.....
Direct Res.	0.751	.....	.....	.....	.....
Cost of Sales	.....	39.972	.....	.....	.....
Uncertainty	.....	.....	3.3453 —	3.0024	.....
Working Cap.	.....	13.709	.....	.....	.....
Uncertainty	.....	.....	1.3623 —	1.3249	.....
N 1	8.001	.....	.....	.....	.....
N 2	10.001	.....	.....	.....	.....
N 3	15.001	.....	.....	.....	.....
N 4	7.001	.....	.....	.....	.....
DP1	40.001	.....	.....	.....	.....
Uncertainty	.....	.....	5.5946 —	4.9046	.....
Gen. Fac.	4.001	.....	.....	.....	.....
Chem.	.....	.....	.....	.....	.....
P 1	0.251	.....	.....	.....	.....
P 6	1.101	.....	.....	.....	.....
P 16	0.601	.....	.....	.....	.....
Chem.	1.951	.....	.....	.....	.....
Water	1.079	.....	.....	.....	.....
Misc. 1	0.074	.....	.....	.....	.....
Misc. 2	0.271	.....	.....	.....	.....
Misc. 3	0.013	.....	.....	.....	.....
Steam	6.223	.....	.....	.....	.....
Elec.	0.643	.....	.....	.....	.....
Plants Rolled	.....	54.252	.....	.....	.....
M	1.251	.....	.....	.....	.....
F. & R.	5.425	.....	.....	.....	.....
Total Perm. Inv.	.....	60.927	.....	.....	.....
Uncertainty	.....	.....	7.4084 —	6.1102	.....
Selling Price	Cents per Lb.	54.899	.....	.....	.....
Uncertainty	.....	.....	4.3236 —	3.9342	.....

FIGURE 8—This computer print-out sheet for synthetic estimate shows the breakdown of the components of mill cost for each step of the process and the uncertainties in these mill costs for plants 1, 2, 3 and 4.

cost elements, uncertainties, scale factors, and case data are entered on the forms shown in Figure 5. The computer print-out for the solution of the base case is given in Figure 8. Similar print-outs would be obtained for each of the case variations shown in Form G of Figure 5.

In the print-out are shown the breakdown of the components of mill cost for each step of the process and the uncertainties in these mill costs (under PLT 1, PLT 2, PLT 3, PLT 4). For example, in step 2 (PLT 2) the sum of the new raw materials entering step 2 is—1.8¢/lb. of product because of a by-product credit; the mill cost of material transferred from step 1 to step 2 (I+E) is 7.02¢/lb. of product, and the combined transferred ingredients to step 2 is 9.22¢/lb. of product; the total ingredients to step 2, therefore, are 7.42¢/lb. (+2.67,—2.58). The cost exclusive contribution of step 2 is 2.48¢/lb. (+0.70,—0.34). Hence, the cost of manufacture of step 2 is 9.91¢/lb. (+2.76,—2.61).

The combined ingredient and cost-of-manufacture figures and the rolled-up-plant, investment, cost-of-sales, and cost-plus-return data are listed under "Total Plants". Thus, the total cost-of-manufacture is 28.49¢/lb. (+2.94, —2.83), the cost of sales is 39.97¢/lb. (+3.35,—3.00), the total working capital 13.7¢/lb. (1.36,—1.32), the total permanent investment 60.93¢/lb. (+7.41,—6.11) and the cost-plus-return (selling price) is 54.9¢/lb. (+4.3,—3.9).

The print-out also gives under "*F* prime" factors a detailed breakdown of the "rolled-up" contribution of basic cost elements to the cost-plus-return. Thus, for example, a change of 1¢/lb. of product in the cost of the first raw material in step 2 (PLT 2) would result in a 1.093¢/lb. change in the overall cost-plus-return. In a like manner a change in steam requirements increasing the cost of steam per pound of product 1.0¢/lb. would result in a change of 3.027¢/lb. in the cost-plus-return and so forth.

Results. Thus, for the effort of preparing the computer input data, the estimator is rewarded with a multitude of results. These include:

1. The effect of yield and conversion in each step on the cost of ingredients, the cost of manufacture, the investment, and the cost-plus-return.
2. The estimating uncertainties in all parts of the cost estimate.
3. The cost-plus-return at any gross return level.
4. The effect of low production rate on cost of manufacture, cost of sales, and cost-plus-return.

In addition, the *f'* factors ("*F* prime" factors in the print-out) give the contributions of such items as ingredients, maintenance, or steam consumption to the cost-plus-return. Research effort can then be concentrated on the large contributors in an effort to reduce them. Also, the base case can easily be revised by hand to determine the effect on the cost-plus-return of changes in the basic cost elements.

Limitations. A high degree of flexibility has been built into this computer program. However, there are limitations as to what can be done with it:

1. The sequence of manufacturing operations is limited to the arrangement shown in Figure 4. For a more complex system several portions of the plant could be combined.
2. The ability of the program to provide proper credit for a salable by-product is limited. As the program is set up, a lower yield will call for higher consumption of ingredients and higher production of byproducts, which may not necessarily be the case.
3. There is no provision for the handling of cases where there are recycle streams between plants. A solution that might be satisfactory in some cases would be to take byproduct credit for the stream from the producing plant and charge it in as an ingredient cost to the plant which uses it.
4. The uncertainties determined by this technique are "estimating uncertainties" only. No allowance is made for deviations from the assumed conditions of yield, conversion and production efficiency for each case. Since the intricate interrelations of these variables would make a rigorous solution extremely difficult, it is preferred to obtain outer limits by calculating sufficient cases to cover the expected range of yield, conversion and plant efficiency—an easy task with a computer.

There is considerable uncertainty in the choice of scale factors, which may change over the range of plant sizes investigated. Therefore, changes in scale and also changes in yield and conversion should be restricted to a moderate range. The plant capacity should probably not vary more than plus 150 percent or minus 60 percent of the base case.

ACKNOWLEDGMENTS

The authors wish to acknowledge the prior effort of others in the Staff Section, especially Harold E. Whitlock, in the development of the cost equations. In addition, they wish to thank Miss J. Ann Sheldon for her cooperation in programing these equations and for her many helpful suggestions.

LITERATURE CITED

[1] *Chemical Business Handbook*, John H. Perry, Editor, McGraw-Hill, New York, 1954

[2] Aries, R. S., and Newton, R. D., *Chemical Engineering Cost Estimation*, McGraw-Hill, New York, 1955.

[3] Zimmerman, O. T., and Lavine, S., *Chemical Engineering Costs*, Industrial Research Service, Dover, N. H.

[4] Pulver, *Construction Estimates and Costs*, McGraw-Hill, New York, 1947

[5] Chilton, C. H., *Chem. Eng.*, April 1950, p. 112

[6] Wessel, H. E., *Chem. Eng.*, July 1952, p. 209.

About the Authors

Jones

Howard E. Jones is a chemical engineer at the Wilmington, Del., experimental station of Du Pont Co. where he is currently working on the development of new chemical processes for commercialization. He received a B.S. degree from Bowdoin State College in 1943, and an M.S. degree from Iowa State University in 1948. In 1943 Jones joined Sylvania Electric Products Co., where he remained until 1946. He has worked for Du Pont since 1948, gaining experience in high vacuum techniques, phase equilibria, analytical procedures, and economic studies.

Kjellmark

Eric W. Kjellmark, Jr., is also a chemical engineer for Du Pont at Wilmington. He is working on process development studies and research liaison for the construction of a new plant. He received a B.Ch.E. degree from Cornell University in 1950, and shortly thereafter joined the Research division of Du Pont's Polychemicals department in Wilmington. He has experience in process development of nylon products and Teflon plastic, and economic and other studies for research guidance.

These Factors Affect Project Success

The risk of new ventures in the rapidly expanding chemical industry can be reduced by carefully considering these factors.

Jack Tielrooy
Fullerton, Calif.

A NUMBER of factors must be considered which affect the risk or chance for success of a growth venture in the chemical industry.

Management must be aware of all these factors, each in its proper place, before making decisions on new projects. These factors will be discussed in detail.

In view of the gigantic size, diversity, and continuing phenomenal growth of the chemical industry, it is no wonder that many newcomers are attracted to the industry. Many companies already established in one or more segments of the industry continuously eye what appear to be "greener pastures" in some other phase of the chemical industry.

All too often, the decision to embark upon a new program involving the ultimate manufacture and sale of of a chemical product is based to a large extent upon emotions. The very important steps of market research, process evaluation, and economic analysis are sometimes by-passed or short-cut. The prime motive for a new venture is, as it always has been, the anticipation of profits. But profits are forthcoming only if the venture is both a technological and a commercial success.

Discussed here are some of the factors to consider in the evaluation of growth projects in the chemical industry.

The chemical industry has enjoyed a phenomenal growth rate since World War II. Capital expenditures for new plant and equipment for the manufacture of chemicals and allied products have averaged more than $1,000 million dollars per year since 1946. On top of this, the industry spends over $400 million per year on research and development, more than any other industry. In terms of assets, the chemical industry ranks fourth among major industries and is outranked only by petroleum refining, machinery manufacture, and food production and processing. Predictions of growth during the next two decades dwarf the present size of the industry.

How the Industry Grows

Growth in the chemical industry may come from one of two sources:

1. From products now commercially available.
2. From new products, not yet commercial.

The sustained high level of expenditures by the industry for research and development leads to growth in both categories. Much of the growth in fact results from improvements in existing products and processes.

Commercial Products. A company's entry into a field involving the manufacture and/or sale of an already-commercial chemical product is usually achieved in one of three ways:

1. By acquisition of an established company in the field.
2. By establishment of a purchase and resale operation.
3. By establishment of a new manufacturing and marketing operation. Acquisition of a company or the establishment of a purchase and resale operation are often stepping-stones to the establishment of a new or expanded manufacturing and marketing operation.

The definition of a commercial product is difficult. The production rate which is considered commercial is usually relative to competitive products. There were 8,850 commercial end chemicals in 1957.[3] Of these only a small fraction were produced in quantities exceeding one million pounds per year.

Most companies entering the chemical industry will base their first venture on existing commercial products. Most of the growth of such companies during the first ten years will come from existing products, either from new ventures or from improvements and expansions of products already marketed. Markets for such products have already been established. In many cases, they have not yet been fully exploited, either geographically or by end-use. In some cases, the growth rate is so high that a newcomer can generally enter the field providing his timing is right. The expense of product and market development is relatively low since much of the work has already been done by others. Manufacturing knowhow is likely to be available on a license or fee basis from domestic or foreign producers. In many cases the necessary knowhow is available without restrictions from consultants, engineering firms, or published sources.

Considerable opportunity yet exists for new producers in many old-line

chemical products. During the years 1939 to 1956, the U. S. production per capita of caustic soda increased 185 percent, sulfuric acid 146 percent, chlorine 470 percent, and ammonia 435 percent, to mention a few. The future promises considerable growth of these and many other existing commercial chemical products.

Perhaps the most significant factor necessary for the successful penetration of an existing market is proper timing. Chemical company managements must be geared to act fast with the aid of sound market forecasts. Sometimes decisions must be made before all the facts are available. To be in a position to move rapidly on existing commercial products, the company must keep abreast of all activities in the fields of interest. They must know market practices, market trends, what other producers are planning, as well as what other would-be producers are planning. And they must keep up with the latest technology in the fields of interest. Even in such long-established fields as ammonia manufacture, there have been significant technological advances in manufacturing processes during the past several years. This has been reflected by a reduction in the cost of plants and a reduction in the economic size of a plant.

New Products. The development of new products often appears as the most glamorous as well as most profitable approach to growth in the chemical industry, particularly to new chemical companies. During the past decade over 4,000 new chemical products have been introduced on the market. Yet only a relatively small number of these are today what might be termed a commercial success. There are many obstacles to be overcome before profits can accrue from the development of new products. The high cost of development and the high odds against success represent the two biggest problems. The mortality rate of new product discoveries is high.

The successful commercial development of a new chemical product historically is based on 500 or more inventions. Of these, perhaps 90 are subjected to extensive laboratory development, and 8 reach the stage of semi-works production and extensive market development. The one which remains may show a sizable return on the total expenditure for research, development, and the construction of manufacturing facilities. This profit must however pay for all of the research and development work which did not lead to commercial success.

There is an average time lag of about seven years from the start of research until the product becomes a successful commercial reality. Of this, an average of five years is devoted to research and development. The balance represents the period of time required for management to act on the project, for the plant to be designed and constructed, and for the job of market development to be carried out. Often, the lag period is significantly longer. Many excellent product discoveries are hampered in their commercial development by the age-old problem of achieving economic manufacturing scale. Large volume sales cannot be attained until price is brought down, and cost of manufacture cannot be brought down until sales volume is up. New products which will compete for the same market currently served by large scale low cost products usually face this problem. New products falling into this category can be commercialized in the normal period of development only by companies willing and able to make substantial capital investments with little or no promise of an early return.

The development time for new products has been significantly reduced only under artificial conditions such as dictated by periods of war or government-financed defense programs. More often, the time for development is longer than seven years due to either lack of risk capital for aggressive development or due to a lag in customer acceptance.

The development, manufacture, and sale of new chemical products may be divided into two main categories:

1. Known products, previously manufactured only on a relatively small scale or synthesized only in the laboratory or pilot plant.

2. New compositions of matter.

The risk of obsolescence of the first manufacturing plant is considerably less if the product is a new composition of matter, which itself is subject to patent protection preventing others from developing and using an improved process. All new products run the risk of early market obsolescence due to the development of cheaper or improved competitive products.

A new company of limited resources must consider the probable cost of a research and development program before it is undertaken. One must not think in terms of a $250,000 research and development budget if the objective is to develop a competitive product to nylon or polyethylene. Such programs, whether or not successful, run into many millions of dollars. And if successful, the company must be willing to risk another $10-20 million in manufacturing facilities before a dollar of profit can be realized.

In order to maximize the returns from research and development, to reduce the mortality rate of inventions, and to reduce the time lag for successful commercial development, the research and development program should be preceded by a careful analysis of the factors affecting probable success. The profitable selection of new products projects for research and development requires an arduous process of screening and elimination, designed to choose the most likely to succeed. Many companies use outside consulting firms to aid them in this process. This helps to avoid one of the most difficult problems faced by every research director, that of determining a research program or even admitting that the odds are poor.

Criteria for Evaluation. The selection of a project for company growth, whether based on an existing commercial product or on a new product, must be carefully judged on the probable economic attractiveness thereof, if successful, versus the inherent risk of a commercial failure. The two criteria normally used to measure the attractiveness of a proposed project are:

1. The probable capital investment required.

2. The probable profits to be derived.

The return required to make the project attractive is in turn a function of the degree of risk involved. A very nominal profit is often considered adequate for a project with little or no risk, such as the manufacture of a product for which the company has a fully developed captive market. On the other hand, the indicated profit from a new product, if successful, must be several times greater.

While all companies make an attempt to analyze the probable profitability of projects, there are all too many evaluations made in which capital requirements are underestimated

and profits overestimated. Estimates of capital requirements should take cognizance of the following items:

1. Cost of the research and development program necessary, including the cost of pilot plants and semi-works plants.
2. Cost of the market research and market development program necessary to achieve the desired sales level.
3. A pro-rata share of research and development, market research, and market development incurred in projects which do not achieve commercial success.
4. Working capital requirements.
5. Pre-operation manufacturing, sales, and corporate management expenses.
6. Startup expenses of the manufacturing facilities.
7. The operating loss sustained during the period between initial plant startup and when production and sales reach the break-even point.
8. The cost of manufacturing, shipping, and distribution facilities.

Many of the above factors are often neglected in economic evaluations of proposed projects, or when considered, are underestimated. Underestimates are most common when estimating the cost of manufacturing facilities. A good checklist of items to consider in estimates of plant cost points out the many costs incurred in the building of a chemical process plant besides the bare cost of battery-limit process facilities.[1]

Similarly, estimates of profits to be derived are often overestimated because all costs of operation are not considered and often the product selling price is assumed at an unrealistically high level. Product selling price must be estimated on the basis of competitive products which have reached large commercial scale and have become competitive.

Many companies make their evaluations of the economics of new projects on the basis of published selling prices of existing commercial products, or of products which serve the same market as a proposed new product. Yet, history shows that a great many products have been consistently reduced in price as volume grew, technology improved, and competition increased. This is well illustrated in a recently published book which gives the price histories on about 140 major industrial chemicals.[2] Some perhaps more startling figures can be found on selected chemicals for 1957.[3] Many of the products listed sold at 4 to 5 times the present selling price during their initial periods of commercialization. In arriving at estimates of the cost of product, it is important that all costs be taken into account. Besides the direct cost of manufacture, the following costs must be considered:

1. Interest on borrowed capital.
2. Selling expense.
3. Distribution expense, including storage costs and products losses.
4. Freight.
5. Discounts allowed.
6. General management expenses.
7. Technical service expenses.
8. Cost of research and development necessary to maintain competitive position in market.
9. Royalties.
10. Allowance for depreciation and obsolescence.

After all of these costs have been deducted from a realistic estimate of gross sales, the result is profit before taxes. From this must be deducted state and federal income taxes.

When all costs have been realistically appraised, it is very seldom that a proposed project will indicate a 2-3 year payout, or a profit on invested capital of 25-40 percent. If the project indicates such a high profitability, an independent appraisal by an outside consulting firm would appear desirable.

Besides a sound economic evaluation of the proposed project, there is much to be gained by a qualitative evaluation of some of the other factors affecting the probable commercial success of the project.

Corporate Policy Factors

Before considering some of the factors which directly or indirectly might affect the probable success of a proposed project, the limitations imposed by corporate management policy should be critically reviewed. Among the more important of these are:

1. The limit of capital requirements the company is able or willing to assume.
2. The return on invested capital expected by the company.
3. The degree of risk the company is willing to assume.
4. How the company looks at projects which improve growth prospects versus conservative low-return projects.

Many of the other factors discussed previously are sometimes also dictated by management policy. If such is the case, they should be clearly made known to operating management levels.

Capital Limitations. The availability of capital for new projects may be limited for any one of several reasons. The first and most controlling is the present size of the company's operations, the profits derived therefrom, and its currently available capital. A company without the resources for a major expansion project is obviously limited to projects of lesser scope. Beyond this, the most often encountered limitations is the result of other demands on available capital. This is particularly true in the petrochemical industry, largely owned or controlled by petroleum companies. The petrochemical project must compete for funds with the many other necessary operating departments of the parent company. The third limitation on capital availability is determined by the financial policy of the company.

Projects for growth in the chemical industry, whether based on present commercial products or based on the development of new products, must obviously be geared to the capital available for carrying on such projects. There is a great tendency, particularly in smaller new companies, to be too ambitious in the size projects considered. This especially applies to research and development projects which, if successful, must be backed by considerable additional investment before a profit can be realized.

Return on Invested Capital. One cannot generalize on what is a satisfactory return on invested capital. This depends to a very large extent upon the company's present operations, the profitability thereof, and the profits possible by expansion of present activities. Nevertheless, the management of a company interested in expanding in the chemical industry should establish a range of levels of return at which they are willing to invest the company's funds. Some companies have done exceedingly well in what are considered to be non-glamorous low-return segments of the chemical industry. Others have done well in attacking only the riskier but

more glamorous and satisfying segments of the industry which promise high profits if successful and the corollary possibility of loss if unsuccessful.

Degree of Risk. Corporate policy regarding expected return on capital investment and the degree of risk they are willing to assume are closely related. In general, the anticipated return is proportionate to the degree of risk involved. The development of new products entails considerable risk: in development of the products, in development of the process to manufacture the product, in the development of markets for the product, and if all the afore-mentioned steps are successful, in the ability to make a profit from the manufacture and sale of the product. In return, the profitability of successful new product developments is considerably higher than average of the industry.

Company Growth Prospects. Another factor often dictated by corporate management is how a proposed project relates to company growth prospects. A chemical company bent on growth is almost always limited to some degree by the capital available for expansion. There is usually much competition for available funds between existing operating departments and proposed growth projects. There are many ways a company can increase its profits in the chemical industry and each bears a different relation to long term growth prospects. Among these are:

1. Expenditures to increase the efficiency and reduce the costs of present operations.
2. Expenditures to increase the manufacture and sale of existing products.
3. Expenditures to develop improved modifications of existing products and thereby increase sales.
4. Expenditures to enter new fields based on known commercial products.
5. Expenditures on research and development of new products and processes.

Each of the above will show a profit, some sooner and some later. Each of the above will more or less promote company growth. Obviously, expenditures to increase efficiency do not create new business activities and diversity in the company's operations. They may yet be very essential to the company's very survival in competitive industry. Management must decide the direction in which it wishes to move. In general, providing the company's present operations are on a reasonably competitive level, the activities through which the company enters new fields are the most conducive to growth.

Ability to Market Profitably

The most important factor to any business enterprise, whether in the chemical industry or not, is the ability to market the product or products profitably. In considering new projects in the chemical industry, there are a number of factors which, if properly weighed and evaluated can markedly reduce the risk of an unsuccessful marketing program. Some of the questions which must be asked are:

1. Does the product fit into the existing sales organization?
2. Does the company possess the necessary product sales and application knowhow?
3. Does the proposed product complement or enhance the sales of existing products?
4. If the product does not fit into the existing line of products, can it be successfully marketed as an item, or is a complete line necessary?
5. How large is the potential market as compared to present total sales?
6. Does the product have end-use diversity?
7. Does the product, or its end-uses, have a high growth rate?
8. Are there a diversity of customers for the product?
9. How many companies and products compete for the same market?
10. Is the product apt to have a high obsolescence factor?
11. Does the company have a captive market for any portion of the proposed product?
12. What are the case histories of competitive companies who have successfully penetrated the market?

Sales Compatibility. The effective sale of chemical products is a highly specialized operation. The type of organization, technical knowhow, technical service required for effective servicing of the market depend both on the product line marketed and on the end-use fields served. In considering a new product or products, an important question is whether they will fit into the present sales organization. Successful penetration of the market with a new product becomes easier, faster, and less expensive if the existing sales organization already serves the end-use fields into which the new product is intended to fit. Market intelligence factors can be developed to a much finer point. If the product cannot be effectively handled by the existing sales groups, this should not necessarily be a deterrent to expansion in this direction. But it must be recognized, market development expenses and selling expenses will be higher.

Sales and Application Knowhow. For many chemical products, considerable product sales and application knowhow is required to perform an effective selling job. First, it must be determined whether the new product requires technical service and application knowhow, and if so, whether such knowhow exists within the organization or must be developed.

Consideration of a large scale already-commercial product normally simplifies the problem of acquiring the necessary product application knowhow. In some fields the necessary knowhow can be acquired with the purchase of licensed processes or through consulting firms. In others, the knowhow is closely held by a few companies in the field, and more difficult for a newcomer to acquire. When considering a new product, the application knowhow is closely related to the technical and sales service on already-commercial competitive products. A company already in a field has a definite edge in the introduction of a new product to that field.

For example, the exploitation of a new plastic must be preceded by testing and evaluation to determine the product's merits with respect to competitive plastics and to develop methods of using the material. Further, its successful introduction to the trade generally requires the adaptation of equipment already in use, which in turn requires a comprehensive knowledge of such equipment.

A common method of acquiring product application knowhow is through the acquisition of a smaller company engaged in the field of interest. There are numerous acquisitions and mergers in which the acquisition of knowhow is the primary motive. Some companies have built large and profitable businesses based on product application knowhow without having a basic raw material or manufacturing position.

On already commercial chemicals, the slowest and most expensive

method of acquiring product application knowhow is through research. Nevertheless, research and development work is necessary to test, evaluate, and confirm such knowhow as may have been acquired from outside sources.

Existing Products Compatibility. If a new product, regardless of whether it is already commercial, complements an existing product line and possibly enhances the sales of existing products, its introduction to the trade is simpler, and usually more profitable. The importance of whether a product fits into the product line of course depends upon the product. In the majority of cases, it is difficult to market a single product without being in the position of offering a complete line.

Potential Market Size. A factor of importance in the consideration of new ventures is the market potential. The degree of effort which is justified in research and development of a new product, or the risk which may be justified by entry into the field of manufacture and sale of an already commercial product, are to a large degree dependent upon the potential market available. Measurement of market potential involves the consideration of many factors, especially in the consideration of a new product. Most significant is the volume of the present markets for products with which the new product may be able to compete, either on a price or quality basis.

For example, the market potential for an improved plastic material is tremendous. It could in many applications compete with most of the large volume structural and building materials such as steel, lumber, glass, stone, and concrete. Since the market for most of the common structural and building materials is many times greater than the sum total of plastics produced, the potential market available to a new plastic material is for all practical purposes unlimited. The new product must of course promise an advantage such as: lower cost, more desirable properties, lower fabrication costs or greater customer-appeal.

An example of a field with a limited market potential is the synthetic detergent field. While this field has enjoyed a tremendous growth rate, it has already captured approximately two-thirds of the soap market and its future growth will obviously be much slower. A would-be newcomer to this field would hardly be justified in spending any appreciable amount of money for the development of a new detergent.

For any given project of expansion, some of the other factors affecting market potential are: the price at which the product can be sold, the marketing area which can be economically covered, the number of competing products, and the number of competing companies.

Growth Rate. Since 1939, production of industrial chemicals has grown at an average of 10 percent per year, compared to a growth rate of about 3 percent for all other industry. Sales of chemicals and allied products have increased during this period from a little over $4 billion to about $24 billion. Many individual products or fields of the chemical industry have enjoyed an even more phenomenal growth while others have had only a nominal growth rate or even declined.

The risk of a new venture is significantly lower if the products considered for manufacture, or their fields of end-use, have both a high growth rate and a large potential market. This applies equally to already-commercial products and to new products. Entry into a competitive field becomes extremely difficult if that field has a low growth rate. The initial manufacture by a company of an already-commercial product usually requires the building of a plant with capacity well in excess of present markets. The plant must be of economic size as compared to competing plants. This often means that a profit cannot be immediately realized. Marketing of the full production within a relatively short period of time, and hence profitability, are considerably more assured if the product or its fields of end-use have experienced a large growth rate and are not yet approaching the saturation point.

End-Use Diversity. Risk of new ventures may be significantly reduced by the selection of products which have a wide end-use diversity, both in the number of fields of use as well as in the number of customers. A larger degree of market stability is assured if the product fits into many fields of end-use. This is fortunately the case for a sizable portion of the chemical industry.

The establishment of a business for the manufacture and sale of a single product which for all practical purposes has only one end-use and for which there are only one or two customers can be risky unless adequately secured by long term contracts. Ethyl chloride is an example of such a product. Most of the ethyl chloride sold goes into the manufacture of TEL antiknock fluid which in turn is manufactured by only two major producers.

Customer Diversity. This can be both an asset and a liability in the marketing of a new product. If there are many potential customers within the marketing area which can be economically served, a producer is not as dependent upon the economic health of his individual customers. On the other hand, selling expense and distribution expense are usually higher when serving a diverse market. Also, the amount of technical service which the producer must supply generally increases more than proportionate to the number of customers.

Competition. The degree of penetration of an existing market which can reasonably be expected is almost a direct function of the number of competitors in the planned marketing area. Competition may come from manufacturers and sellers of identical products or may come from manufacturers and sellers of products which compete directly for the same end uses. The fewer the number of competitors within the planned marketing area, either direct or indirect, the better are the chances of rapid market penetration, unless other factors indicate to the contrary. In some cases where competition appears to be lacking, the necessary knowhow for product manufacture and product application are closely held and difficult to acquire.

Product Obsolescence. Possible rate of obsolescence is an important factor to be considered in the evaluation of new products, or products which have only recently become commercial. The amount of research and development

which may be justified on the development of a product and a manufacturing process for the product will depend, to some degree, on the probable or possible rate of obsolescence. Proper timing, low research and development costs, low investment in manufacturing facilities, and high profit margin are essential if a product is subject to early obsolescence.

Examples of products in which the possibility of obsolescence must be considered include agricultural chemicals (other than basic plant foods), lubricating oil additives, synthetic fuels and lubricants, and pharmaceuticals. Any new product is of course subject to obsolescence due to the development of a superior competitive product.

Case History Studies. A valuable tool to management in deciding for or against a proposed new project is a collection of case histories of other companies in entering the same field or introducing a similar product. While it is possible to write down many generalizations which may serve as guides to profitable growth in the chemical industry, it is also possible to write down almost as many exceptions. Case histories are particularly valuable when applied to new ventures or new products which failed. The reasons for a project's failure are often more significant than the reasons for its success.

Competitive Manufacturing Position

If analyis of the factors affecting the risk and probability of success in the marketing of a product is favorable, the company's manufacturing position must be critically evaluated. It is essential of course that manufacture of the product return a reasonable profit on the investment in plant facilities, a return commensurate with the project's risk. As in the marketing of a product, there are a number of factors which, if properly evaluated, can markedly reduce the chances of making an ill-advised investment in manufacturing plant. Some of the important questions are:

1. Is the break-even cost of manufacture competitive with other producers of the same, or similar, products?

2. Is the break-even rate of production sufficiently low to assure at least a minimum profit during the period of market development and market penetration?

3. Is the required capital investment for plant facilities, expressed as dollars per annual unit of production, comparable to competitive plants?

The ideal situation from a risk standpoint would be a low break-even manufacturing cost (less than 50 percent of selling price), a low break-even rate of production (less than 50 percent of anticipated sales), and a capital investment in plant facilities which is no higher, per annual unit of production, than that of most of the competitive companies.

Scale of Operations. One of the most critical problems facing a company bent upon entering a new field is the establishment of manufacturing facilities of economic scale. Initial markets limit production rate. Often such limits are below the break-even production rate, i.e. the production rate at which manufacturing cost equals netback. The new producer faces a serious problem in establishing the capacity of the manufacturing facilities to be built.

If the plant is sized for initial anticipated market requirements, the plant will most likely have a high break-even cost, and show a low return on investment. As the market grows more competitive, and selling price drops, a plant which is too small may end up as a losing operation.

On the other hand, if the would-be producer sizes his first plant for several times the initial anticipated sales volume, the rate of production at which the plant breaks even is substantially higher. Break-even cost at full production rate will of course be much lower. But the company will first be faced with sustaining losses on the operation for the period during which sales are below break-even production rate.

As a general rule, the construction of plants of lower capacity than the majority is undesirable unless other compensating advantages exist. There are of course many situations where other factors will outweigh the unfavorable economics of low plant capacity.

Raw Material Position. The importance of the company's raw material position must be considered for all projects which involve substantial investment in manufacturing facilities. For many products, a basic raw material position is essential. For such products, much of the profits derived from the manufacture and sale is actually obtained from the production and processing of raw materials.

Ammonium sulfate is a good example of such a product. The manufacture of ammonium sulfate from purchased ammonia and purchased virgin sulfuric acid is not normally an economic operation. With sulfuric acid at $23.50 per ton and ammonia at $88 per ton, the raw material cost for ammonium sulfate amounts to $40.50 per ton excluding any freight paid on the raw materials. This compares to a current f.o.b. bulk price of $34 per ton for ammonium sulfate.[4] The profitability of such a product is obviously dependent upon a unique raw material position.

On the other hand, there are many chemical products which can be profitably manufactured without a basic raw material position. These generally fall into one of two classes:

1. Products in which raw materials represent only a small fraction of the manufacturing cost, usually less than 40 percent.

2. Products in which the requirements of raw materials represent only a small fraction of the total market for such raw materials.

For any project under consideration, the importance of raw material position should be evaluated in terms of break-even cost, in terms of break-even production rate, and most important of all, in terms of the existing or potential competition.

Manufacturing Knowhow. The availability and adequacy of manufacturing knowhow are important to the success of a new manufacturing operation. The two most common avenues for obtaining knowhow on a manufacturing operation are:

1. By purchase.

2. Through research and development.

On products which are already manufactured commercially, the development of manufacturing knowhow can seldom be justified in comparison to the purchase of such knowhow, if available. On processes for which the manufacturing knowhow is closely held, and subject to patent protection, the necessary manufacturing knowhow and rights can generally be obtained under a license agreement from either domestic or foreign producers. On processes where patent protection has expired, the sources of

knowhow include consulting firms, engineering contractors, and published literature. The proper selection of competent personnel with experience in the proposed field of manufacture further complements the acquired knowhow.

Often, research and development work are indicated as necessary to confirm certain aspects of the acquired manufacturing knowhow. Only seldom can the independent development of a manufacturing process be justified for a product which has been commercial for some time. A fact often overlooked is that a plant designed on the basis of laboratory and pilot plant data is seldom competitive with one based on actual commercial plant experience. Many chemical process plants being built today cost less than a similar plant did ten to fifteen years ago, in spite of a substantial increase in construction cost indices.

The development of manufacturing processes for new products, not yet commercially manufactured, can often be accelerated and made more economic through the application of commercial manufacturing knowhow on similar products and processes. A more realistic appraisal of embryonic processes can also be made by comparison with similar commercial processes.

Manufacturing Organization. A factor to be considered is how well a proposed new product fits into the existing manufacturing operation. Almost any large scale manufacturing operation will in itself justify the establishment of whatever type of organization is required to efficiently manufacture the product. On the other hand, many smaller scale operations can be economic only if they can be fitted into an existing organization. And often, they do not fit.

Factors which may lead to incompatibility include such things as company construction and safety standards, geographic location with respect to raw materials or markets, and type of labor requirements. Some types of operations in the chemical field are carried on in what might be termed a "shoe-string" operation with minimum construction standards, minimum safety standards, and with low skill labor. When such an operation is subjected to the more exacting requirements of a major petrochemical manufacturer, it can no longer be economic.

While a separate organization, designed specifically to compete, can always be established, careful consideration must be given to whether the proposed product or products justify the establishment of such an additional organization.

Capital Investment Requirements. Since the profits to be derived from a proposed operation are almost always equated to capital investment requirements, it becomes essential that all of the items of cost be taken into account. Initial estimates of the cost of a manufacturing facility almost always tend to be low. In the case of products which are already commercial, low estimates are usually the result of incomplete scope definition. The costs involved in site preparation, buildings, utilities plants, storage facilities, auxiliary facilities, offsite piping, and other similar costs are often overlooked or underestimated. Then there are numerous other costs such as construction interest, startup alterations, spare parts, allowance for labor and material escallation, automotive equipment, building furnishings, and startup expenses which are frequently not considered.

In the case of a new process, which is not yet fully developed at the time the project is conceived, cost estimates are often even further off due to over-optimism as to the outcome of the ultimate process development. In the preparation of estimates for new processes, an adequate contingency allowance should be included for the inevitable plant alterations which are found necessary after the plant is complete and for the expense of a longer-than-normal startup period.

Other Manufacturing Factors. Numerous other factors must enter the consideration of a new manufacturing facility besides those mentioned above. Process obsolescence is always a possibility with a new commercial product. An example of early obsolescence is the commercial production of butadiene by chlorination of butenes followed by pyrolysis. The accelerated development during World War II of improved processes and the war time construction of butadiene capacity to supply the synthetic rubber program made the first commercial plant obsolete within a few years.

Geographic location has been briefly considered. Besides the importance of location with respect to raw materials and markets, other location factors of importance include such things as utilities supply, labor supply, and transportation facilities. All of these are so well recognized that further elaboration is unnecessary.

Conclusion. A number of factors have been discussed which affect the risk or probability of success of a growth venture in the chemical industry. Many of these factors are often important and many are not. And one can list exceptions to almost any generality expressed. The point is that chemical company managements should be aware of all the factors which might affect the success of a new venture. Each company should, in the light of their own operations, policies, and financial position decide for themselves on the importance of such factors.

ACKNOWLEDGMENT

Specific acknowledgments in an article of this type are difficult since many of the ideas presented have appeared in the numerous excellent articles which have been published over the years in the many publications which cover the chemical industry.

LITERATURE CITED

[1] Chemical Engineering Progress, 52, No. 5, p. 187 (1956).
[2] "Industrial Chemicals," by W. L. Faith, Donald B. Keyes, and Ronald L. Clark (2nd Edition, John Wiley & Sons, Inc., 1957).
[3] "The Chemical Industry Facts Book," Manufacturing Chemists' Association, Inc. Washington, D. C.
[4] Chemical and Engineering "Quarterly Report on Current Prices," March 31, 1958.

About the Author

Jack Tielrooy is a consulting chemical engineer with offices in Fullerton, Calif. A graduate of California Institute of Technology, he has worked in technical and economic feasibility studies, and chemical plant design. Tielrooy is a former vice president of Brea Chemicals, Inc., and has also worked for Shell Chemical Corp. and Union Oil Co., He is a member of the Commercial Chemical Development Association and the AIChE.

The Mechanism of Explosions In Starting Air Lines

Fire resistant lubricants will help to stop explosions in starting air lines on large internal combustion engines.

Robert S. Ridgway
Standard Oil Company of California
Whittier, Calif.

EVER SINCE the practice of starting large internal combustion engines began by rolling them with compressed air admitted directly to the power cylinders, industry has been plagued by explosions in the compressed air lines. Fortunately, these explosions are very infrequent. But their violence is usually so great that they are much to be feared when they do occur, as they are a grave hazard to personal safety and equipment.

The natural gasoline industry, operating several million horsepower of such engines, has been greatly concerned with such explosions for many years, and numerous studies have been made. The NGAA has made two surveys within the last decade. Recent experimental work has thrown some very strong light on the probable mechanism of these accidents. Some relatively new products have been made available which could lead to the end of such accidents. By reviewing the operating experiences and research work—the author believes—we now have sufficient evidence at hand to fully explain these accidents.

NGAA Survey. In the 1957 survey of the NGAA, 53 companies were questioned. Twenty had experienced one or more starting air line explosions. All used the same general types of air compressors. No correlation between those having had accidents and those having none could be found between the alternates of any of the following practices: Air suction from inside or outside of the building; use of an oil bath air filter; connections to the engines made to the top or bottom of the air headers; frequency of overhaul of the air compressors; schedule of blowing down lines or tanks; use of aftercoolors for the air stream; requiring the air to flow through the air storage tank instead of having it float on the line through a tee.

Of the 20 having experienced explosions, 11 have used bursting discs on the system. Nine have stated that this equipment did not always prevent the air line from rupturing; one felt that it did, and one was not sure that there would have been a pipe line failure if the rupture disc had not been used. One reported pipe line rupture without any bursting of the disc. So from all of the above mentioned practices, many of them good, there was no helpful clue which would lead to the solution of the problem.

One pair of questions, however, brings forth answers which provides a rather strong agreement. Four operators have lubricated their compressors with a mixture of soap and water, and all four report no air line explosion occurring while the soap solution was being used. One operator, who is one of the country's largest, has been using this type of lubrication for 30 years, hence, his record is quite impressive. Another significant question asks if air line explosions have always occurred while starting engines. In this case 18 answered yes, one said no, and one said "not always."

Returning to the subject of soap

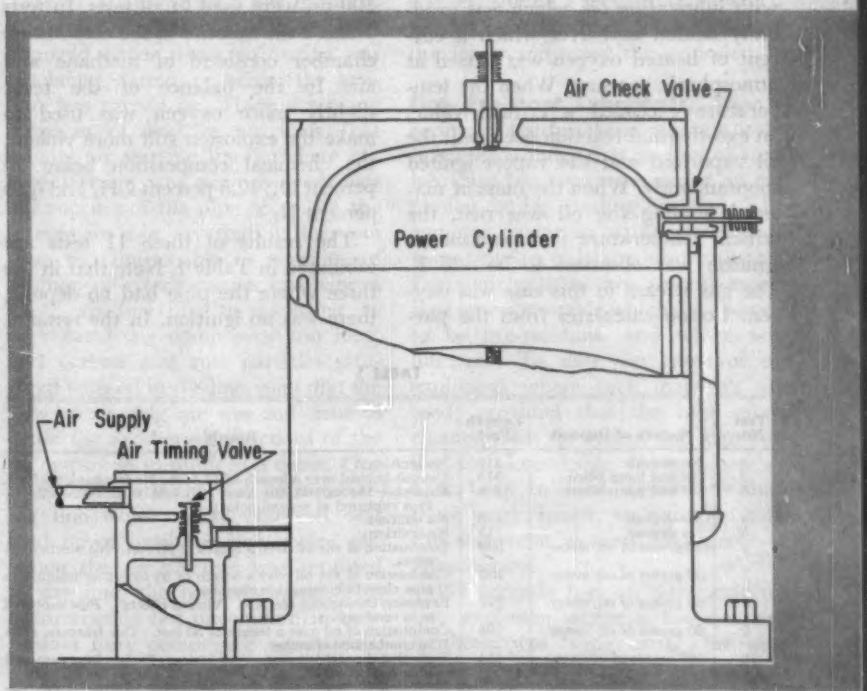


FIGURE 1—Conventional air starting system.

lubrication, one is entitled to ask why, if such a lubricant has done a 100 percent job, it is not used universally? The answer to that one is twofold. Soap is not suitable for crankcase lubrication; hence, to use this material, all of the common vertical or vee type splash lubricated compressors must be replaced by equipment, probably double acting, where the cylinders are force fed from a lubricator. This would normally be a major expense item. Secondly, not all users are satisfied with the performance of the soap solution; and some have deserted it, reporting that the soap was too troublesome in the valves and in the lines.

French Research. In July, 1952, R. Loison presented to the Seventh International Conference of Directors of Safety in Mines Research, a paper entitled "The Mechanism of Explosions in Compressed Air Pipe Ranges."[1] It so closely describes the phenomena encountered in air starting systems as to be of inestimable value to those concerned with this problem.

Thresholds. Loison made a number of experiments. The first group dealt with a mass of material, saturated with lubricating oil, which was gradually heated and over which a current of heated oxygen was passed at atmospheric pressure. When the temperature exceeded a critical value, an exo-thermal reaction occurred; the oil vaporized and the vapors ignited spontaneously. When the mass of material holding the oil was rust, the critical temperature for spontaneous ignition was observed to be 320 F. The gas stream in this case was oxygen. Loison calculates from the partial pressure of oxygen in the air that similar results would result from the substitution of air at 70 psi. This was confirmed by passing an air stream over deposits collected from one of their compressors. The threshold of oxidation was found to be at 310 F. at a pressure of 100 pounds. This process of the exo-thermal reaction of oxygen on oil and carbon has been the subject of other papers and is well covered by the U. S. Bureau of Mines in its report R. I. 4465 published in June 1949.[2]

Loison's next experiment consisted of igniting an explosive gas-air mixture in a short pipe, separated by a thin membrane from various longer lengths of pipe containing air. The air pipe was either clean, or the walls were smeared with a thin coating of lubricating oil, or the oil was placed in long trays and laid along the bottom of the pipe. In all cases the pipe was 10 inches, with ¼-inch wall thickness. The combustion end was 13 feet long. The test ends varied in length from 115 feet to 311 feet with closed ends. The separating membrane was calculated to rupture at 85 psi and was prevented from doing so during the charging period by pumping up both ends of the pipe simultaneously. Initial pressures of 100 psi were used in all tests. In tests 1 and 2 the mixture in the combustion chamber consisted of methane and air. In the balance of the tests, slightly more oxygen was used to make the explosion still more violent, the chemical composition being 25 percent O_2, 12.5 percent CH_4 and 62.5 percent N_2.

The results of these 11 tests are tabulated in Table 1. Note that in the three where the pipe had no deposit, there was no ignition. In the remaining 8 tests, 2 showed burning without mechanical effects, and in 6, the explosions were violent and the pipe was ruptured, usually at several points.

TABLE 1

Test No.	Nature of Deposit	Length (Feet)	Result
1	No deposit	311	No ignition.
2	Oil and lamp black	311	Deposit burned over a length of 13 feet. No mechanical effect.
3	Oil and lamp black	311	Explosion throughout the pipe. Violent mechanical effects. Pipe ruptured at several points.
4	No deposit	115	No ignition.
5	No deposit	115	No ignition.
6	30 grams of oil/meter	230	Combustion of the oil over a length of 33 feet. No mechanical effect.
7	30 grams of oil/meter	230	Combustion of the oil over a length of 50 feet. One fracture in pipe close to combustion chamber.
8	60 grams of oil/meter	197	Explosion throughout the pipe. Violent effects. Pipe ruptured at several points.
9	60 grams of oil/meter	164	Combustion of oil over a length of 50 feet. One fracture, close to combustion chamber.
10	180 grams of oil/meter	164	Explosion throughout pipe. Very violent effects. Pipe ruptured at several points.
11	180 grams of oil/meter	148	Explosion throughout pipe. Very violent effects. Pipe ruptured at several points.

Speed. From the observations of Loison, also of Elting Henderson in his paper to the PCGA in 1941 entitled "Combustible Gas Mixtures in Pipe Lines"[3] and from the work of other authors, the speed of pressure waves in pipe lines can reach several times the speed of sound. Loison measured velocities up to 4,000 feet per second; and Henderson measured them as high as 5,300 feet per second, or almost Mach 5. Where the initial explosion is sufficiently severe to initiate the shock wave near or above the speed of sound, the temperature within the shock front can be sufficient to vaporize and inflame the oil deposit in the pipe, causing combustion. The initial temperature of the air will, of course, have a bearing on this phenomenon. The combustion will, in turn, serve to propagate the shock wave which at higher speeds will attain higher temperatures and cause detonation within the pipe.

Loison calculated a shock wave temperature in the order of 870 F. in a wave front traveling at 3,300 feet per second. Actually, he observed that the speed of the shock wave when initiated by the ignition of the combustible charge was in the order of 1,300 feet per second. From this initial velocity his measurements showed the shock front accelerating to 4,000 feet per second. When detonation ruptures the pipe, the pressure wave appears to momentarily slow to the speed of sound; but the expansion connected with the rupture and possibly other phenomena accelerates the wave front again to several Mach numbers. The rupture pattern is thus repeated. It should be noted in passing that rupture does not terminate the explosion; but instead, appears to intensify it and make it repeat.

The famous mid-continent pipe line explosion of 1939 serves to illustrate this fact. In this explosion some 32 miles of 10-inch empty oil line was ripped apart in ruptures at various intervals when a pig was being forced through by compressed air. Henderson found that the pipe line explosions could be propagated re-

gardless of whether or not the far end of the pipe was open or closed. This was probably due to the inertia of the gas in conjunction with the speed of the mechanism. When no detonation occurs (merely combustion within the pipe) or when a second detonation does not occur following a rupture, the accelerated shock wave appears to slow down to around the speed of sound.[1]

While discussing the phenomena of such waves, it should be of value to quote an observation of Loison, who says "It is not necessary to imagine the flame front as being close to the pressure wave front. The successive rise in pressure as a result of the inflammation of new portions of combustible matter are, in effect, capable of maintaining a shock wave even if this is a certain distance in front."

Pressure. It has further been calculated that with a condition of detonation, terminal pressures in the order of 100 times the initial pressure may be expected. Loison did not measure final pressure, but with some assumptions as to the kind of pipe used, we calculate his bursting pressures to be around 2,400 psi. Henderson,[2] however, did measure terminal pressures as high as 9,000 psi, thus proving the factor of 100 for the case involving detonation. Pressures resulting from simple combustion of hydrocarbon-air mixtures can only be expected to reach a maximum pressure of 2 to 6 times the initial pressure.

Application. The application of the foregoing research work and observations to the phenomena of explosions in air starting lines is not difficult. We need only to determine the cause of the initial explosion within the system which will promote the shock wave. We then have our puzzle assembled, for we can depend upon the air compressor to supply the coating of lube oil to the pipe walls. It is our opinion, shared by many others, that a stuck or leaking air check valve permits the engine being started to pack the section of line between the check and the air timing valve (Figure 1) with explosive mixture. When this is fired from the power cylinder, the resulting pressure wave forces itself upstream through the timing valve and into the main air line. Thus, the whole starting system becomes parallel to that used in the experiments of Loison. When the circumstance of a malfunctioning check valve is coupled with a fuel-air mixture in the combustible range and good flame propagation in the power cylinder, the proper set-up is laid for explosions in the pipe system similar to those shown in Loison's experiments.

Our observations of air line explosions which have occurred while engines were being started coincide with the experiments of Loison in many ways. In the majority of such accidents where we have seen the results shortly afterward the pipe has been ruptured at several places. Frequently the line between such bursts would contain a valve or fitting which might have been expected to have ruptured at a fraction of the bursting pressure of the pipe. Yet, these did not fail because the detonation wave had not occurred at that particular spot. We once saw a 125-pound brass check valve on an air line adjacent to the power cylinder being started which was undamaged. A series 30 plug cock in the starting line against the building wall was shattered. The shock wave had apparently not gained sufficient speed to cause detonation until it had traveled some distance from the engine. Pressure from combustion alone was not sufficient to rupture the check.

There appear to be a few instances of air line explosions and fires which occurred either when an engine was not being started, or before the ignition was turned on. There are many instances of fires in air lines (not usually air starting lines), where engine starting was not involved; nor did rupture of the pipe occur. Of the former we can say that it does not seem too improbable to conceive of a chain of circumstances involving a "hot" air line due to operating an overheated air compressor too long, and carbon and rust particles saturated with oil in the line, such that the flow of starting air was sufficient to cause the exothermic reactions of the oil or carbon to result in a flame. One operator reports a fire in an air starting line which, when observed, was bled down until the line cooled off. When the air pressure was returned to the line, the fire continued. This occurrence is not uncomonm in continuous duty compressed air systems. Fire, once started, continues to vaporize the oil to its ignition point.

Users of air at high pressure must be careful not to introduce a shock wave into a high pressure line by sudden opening of a plug cock. The Walter Kidde Company has done some research work along these lines and has published a report[4] in which they show that sudden admission of air at pressures above 1,300 psi caused combustion in an aluminum tube 1-inch in diameter by 10 inches long when the tubing walls were covered with a film of oil. Not long ago a local aircraft concern was charging small containers from a large storage tank of air at approximately 7,000 psi pressure. The operators were somewhat disturbed one day when, upon opening the charging cock, the main supply tank grew suddenly hot and shed its coat of paint. In both cases it is likely that the sudden acceleration of the high pressure air had set up a shock wave which had, in time, caused the combustion. In one study, we have come across a few instances where operators have been insistent that the explosion occurred at the moment the starting air cock was opened, or that the engine was being rolled with air, with the ignition, or the fuel, or both being shut off at the time of occurrence. This raises the speculation as to whether the opening of either the air cock, or the timing valve operated by the engine cam could, under an ideal set of circumstances, initiate a pressure wave which would start the mechanism described previously and cause the explosion.

Fire Resistant Lubricants. After a review of the foregoing research tests, it is little wonder that no user of soap lubricant has ever experienced an explosion in his starting air line. The common factor in all of the mechanisms appears to be the lubricating oil. Fortunately there are several materials now obtainable which are claimed to be fire-resistant, and which will lubricate. To date we know of no explosions where such materials are used, provided that the lube oil is cleaned from the system and kept out. To my knowledge these materials have been in such service less than three years; hence, we must not take this statement as conclusive proof of effectiveness.

We recently had an interesting air line explosion where a fire resistant synthetic was being used. One pipe rupture only occurred, rather close to the engine. A rupture disc a short distance away failed. The balance of

the line stayed in good shape. Close examination afterward showed that lube oil was collecting in the cam case and running down the stem of the inverted air starting valve, and thus entering the air line during the period of normal engine operation. The engine air check valve stuck during the start; hence, this was a perfect "set-up" for an air explosion. Our Mid-Continent operator, who has used soap for 30 years, tells of a similar experience, where lube oil entered the air system in a like manner and caused an explosion.

Our accident provoked two interesting observations. The first was that, although we did not dismantle the balance of the line to inspect, it did not appear that combustion occurred very far beyond the location of the engine being started. There were no series of ruptures throughout the rather extensive air system, which might be expected under operation with lube oil. From this point of view, then, the fire resistant lubricant looked promising. The second observation was that a 300-pound rupture disc did not protect a 1½-inch pipe nipple against bursting. A similar nipple from the same line was subjected to a hydrostatic pressure of 8,300 psi (the limit of our test stand) and it did not fail. If a 300-pound rupture disc will not protect 8,300 psi plus pipe, then (1) the internal phenomena could not in any sense be called "controlled combustion," nor (2) can we look to rupture discs to protect us from these accidents.

We would warn against using these fire resistant lubricants without making two thorough checks: First, thoroughly clean the oil, carbon, scale and rust from the pipelines, else a false feeling of security is likely to exist when actually the lube oil impregnated rust, scale and carbon within the pipe wall can lie for years waiting for just the right set of circumstances to "set it off." In most of our plants we circulated a hot detergent throughout the air system until it became clean.

One of the large Mid-Continent gas pipe line operators recently switched his starting air compressors to a fire-resistant lubricant, and engaged the services of a chemical contractor to clean the systems in all of his stations. The oil, carbon and other organics were first removed with a strong caustic soda solution, followed by a flush with water and an air purge. The lines were then filled with inhibited hydrochloric acid of 20 to 30 percent strength, to remove all rust and inorganics. Water was again used to remove all the chemicals. This was a big job and it required about 30 hours per station, but when it was completed the operator had no concern over the possibility of explosions caused from the residual material within the pipelines.

Secondly, all possibility of lube oil entering the air system must be eliminated. Inspection of various makes and models of large engines reveals that some of them permit crankcase lubricant to flow into the air distributing mechanism; and one provides an oil connection into this device to lubricate the distributing disc. Obviously the lubricant at all such points must be fire resistant, and various and sometimes ingenious methods must be employed to prevent the crankcase lubricant from entering the air system and nullifying the effect of the fire-resistant lubricant.

Combustion Pressure. Although we may be able to remove from the pipe line the material which makes detonation possible, it may not be so easy to eliminate the mechanism which sets it off. It is like saying that we can eliminate the dynamite, but not the fuse. By the fuse, we mean the mechanism of the malfunctioning check valve which permits explosive mixture to enter the adjacent air piping, and, when ignited, cause the initial pressure wave. If this combustion pressure within this pipe can be hazardous, then we must be concerned about it. It is unlikely to expect pressures within the piping adjacent to the power cylinder in the event of a faulty check valve to be materially different from those within the power cylinder. With high compression engines we would expect such pressures to be in the order of 600 psi under conditions of perfect mixture strength. For the pipe there will be no problem of containment of such an instantaneous pressure; but for valves and checks, it will be advisable to install fittings capable of withstanding such pressures. Without the material to provide the energy to propagate the shock wave, it should become harmless rather rapidly, although we are not prepared to say just how great a distance this may be. However, it does not become a major item to use Series 30 valves and fittings on air lines. More frequent servicing of the engine check valves, or the addition of a second check adjacent to the first one, or both, should reduce the incidence of packing explosive mixture into the air line.

In the author's opinion, at long last the mechanism of the deadly and treacherous starting air line explosions is understood; and there is material available which will allow us to be in control of the situation.

Original presentation was before the CNGA, April 3, 1958, Downey, Calif.

LITERATURE CITED

[1] "The Mechanism of Explosions in Compressed Air Pipe Ranges" R. Loison. Centre d'etudes et Recherches des Charbonnages de France. Paper No. 26, U.D.C. 541.126:621.53:622. Presented to The Seventh International Conference of Directors of Safety in Mines Research, Buxton, England, July 1952.

[2] "The Carbon-Oxygen Complex as a Possible Initiator of Explosions and Formation of Carbon Monoxide in Compressed Air Systems" by Busch, Berger and Schrenk, Bureau of Mines paper R.I. 4465, June 1949.

[3] "Combustible Gas Mixtures in Pipe Lines" Elting Henderson, 1941 Proceedings of the Pacific Coast Gas Association.

[4] "Oil Combustion Phenomena in High Pressure Air Systems" M. W. Weibel, Walter Kidde & Co. Inc., Report R-831 copyright 1952.

About the Author

Robert S. Ridgway has been working principally with internal combustion engines, compressors, pumps and their related equipment since receiving his B.S. degree in mechanical engineering from the California Institute of Technology in 1924. He has worked with the Natural Gasoline Department of Western Operations, Standard Oil Co. of Calif., since 1925 as a mechanical engineer. Since 1953 that department has been part of the Producing department and Ridgway has become senior staff mechanical engineer. In 1957 he was given the status of professional engineer by his company in recognition of his work. Other articles by Ridgway have been published in PETROLEUM REFINER.

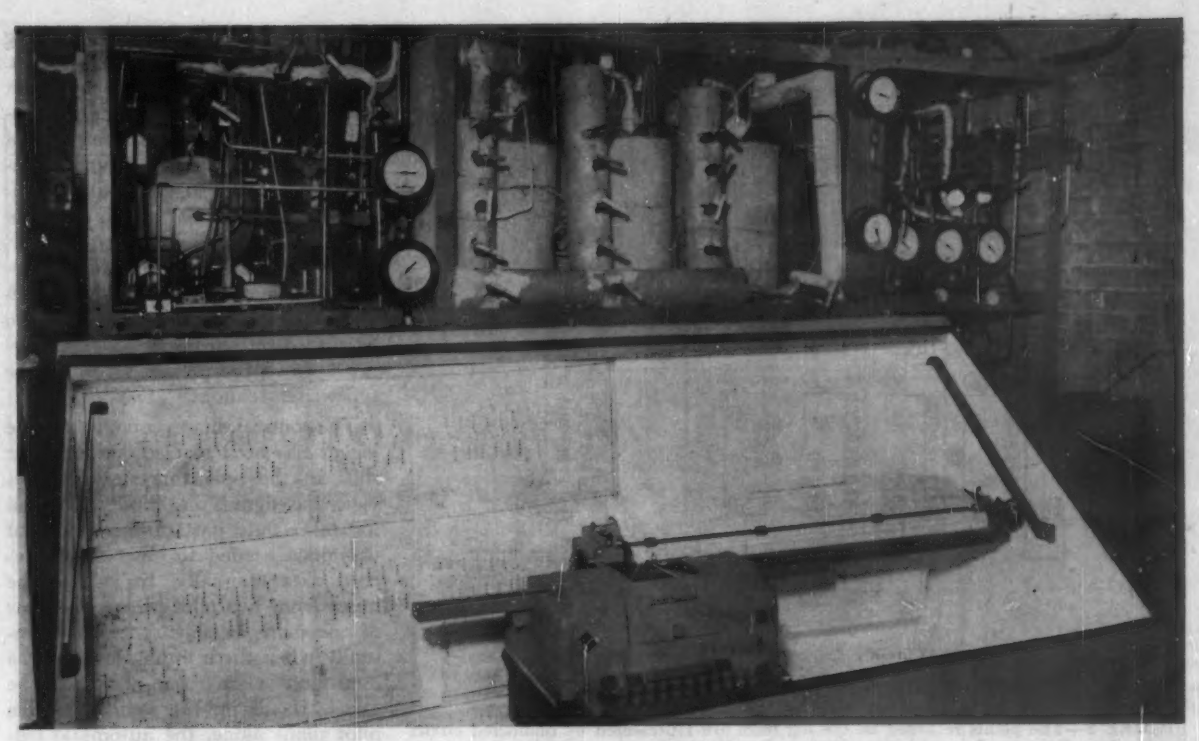


FIGURE 1—The automatic typewriter readout is encased in a dust-proof cabinet near the pilot plant.

Data Logger Tested in Pilot Work

Sohio says its operation has increased accuracy, reduced data collection time and lowered operating costs. Here is the story of a data logger used with a fixed bed catalytic pilot plant.

John J. Arendt and John Savoy
The Standard Oil Company (Ohio), Cleveland

MORE THAN a year of operation at Sohio's Process and Product Development division laboratory proves the value of an automatic data logger in achieving higher accuracy, reduced data collection time and lower operating costs in pilot plant operations. The reliability and maintenance of our data logger has been above expectations.

In January, 1956, a dual-purpose catalytic pilot plant went on-stream at Sohio's laboratory. The unit employs a fixed bed catalyst. It can operate as a single reactor hydrogenator or as a multi-reactor catalytic reformer. The pilot plant is used to find optimum conditions for Sohio's refinery units.

A primary duty of the operating team is to adjust and record key temperatures, pressures, and liquid levels in the pilot plant. Conventional instruments were originally used for unit control and data collection. In August, 1956, an automatic data logger was added. It has proved the value of automatic logging in pilot plant units.

Higher Accuracy and Lower Cost. The logger was purchased to meet the goals of: increased accuracy, de-

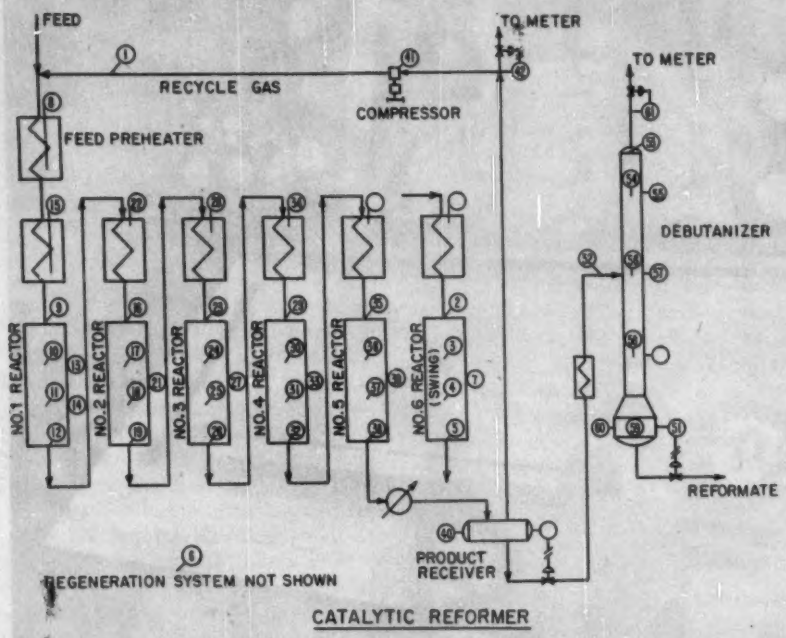


FIGURE 2—The points recorded on the log form are represented by numbered circles in this flow diagram of a catalytic reformer pilot plant.

creased data collection time, and lower operating costs. All of these have been met.

First, the conventional temperature records, with a 0-1200 F scale, are accurate only to ±5 degrees. This was not sufficient. With the data logger, temperatures are correct to ±3 degrees. (The over-all accuracy of the logging system itself is ±0.25 percent for electrical inputs and ±0.5 percent for pneumatic inputs.)

Another feature of the logger is that data are recorded very rapidly. This is very important in pilot plant work. Because of the many instruments to be read, data were not collected quickly enough. A set of readings took 20 to 30 minutes to observe and record manually. The logger now scans and records these values in less than three minutes.

While the faster and more accurate readings have made the pilot plant a more useful development tool, the cost of automatic logging was justified on manpower savings. The logger was designed to log about 180 points. This would permit recording about 60 points from each of three pilot plant units. Thus, the initial cost of the logger could be divided among three units. One of these, a fluid catalytic cracker, started on data logger operation before the hydrogenation-catalytic reformer. A third pilot unit is yet to be placed on automatic logging. Figure 1 shows the present set-up of the typewriter readout.

The outstanding economy of the logger has been to free one man per shift in the operating staff. To review the figures on the typewritten log takes only part of the time that was once needed to observe and record data manually. In logging the input from two pilot plants, the time of one man per shift is saved. Eventually when three units are logged, a man and a half per shift will be saved. Based on the savings to one pilot plant alone, the automatic logger should pay for itself in less than two years.

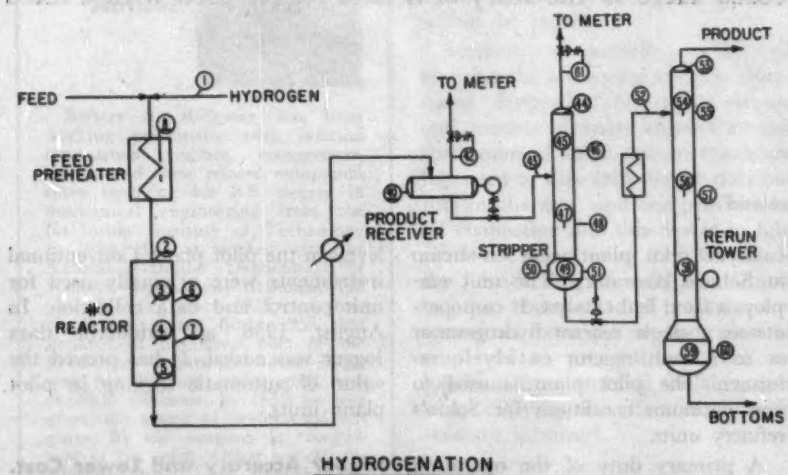


FIGURE 3—The pilot plant is dual-purpose. Here is the way the equipment is arranged for hydrogenation studies.

What the Logger Does. The points recorded on the log form are represented by the numbered circles in Figures 2 and 3. There are 58 temperatures, two pressures, and one liquid level that are logged. The blank circles represent other points that could also be logged if desired. All these points are recorded on the log form shown in Figure 4. The numbers on the flow diagrams, Figures 2 and 3, correspond to the numbers on the log form.

An adjustable timer is provided so that the readout interval ("TIME in the left-hand column of Figure 4) can be varied from continuous to once per hour by setting a single dial. Thus, the logger can record continuously during an upset or out-of-limits condition. Previously, readings were often neglected during upsets. A readout cycle may also be started at any time by pushing a manual start button. Note in Figure 4 a readout interval of about 25 minutes has been set, with an extra manual readout at 0814.

The electric typewriter is located in a dust-proof cabinet (Figure 1) at the edge of the pilot plant. It is a standard office machine with a 26-inch carriage and a solenoid actuator

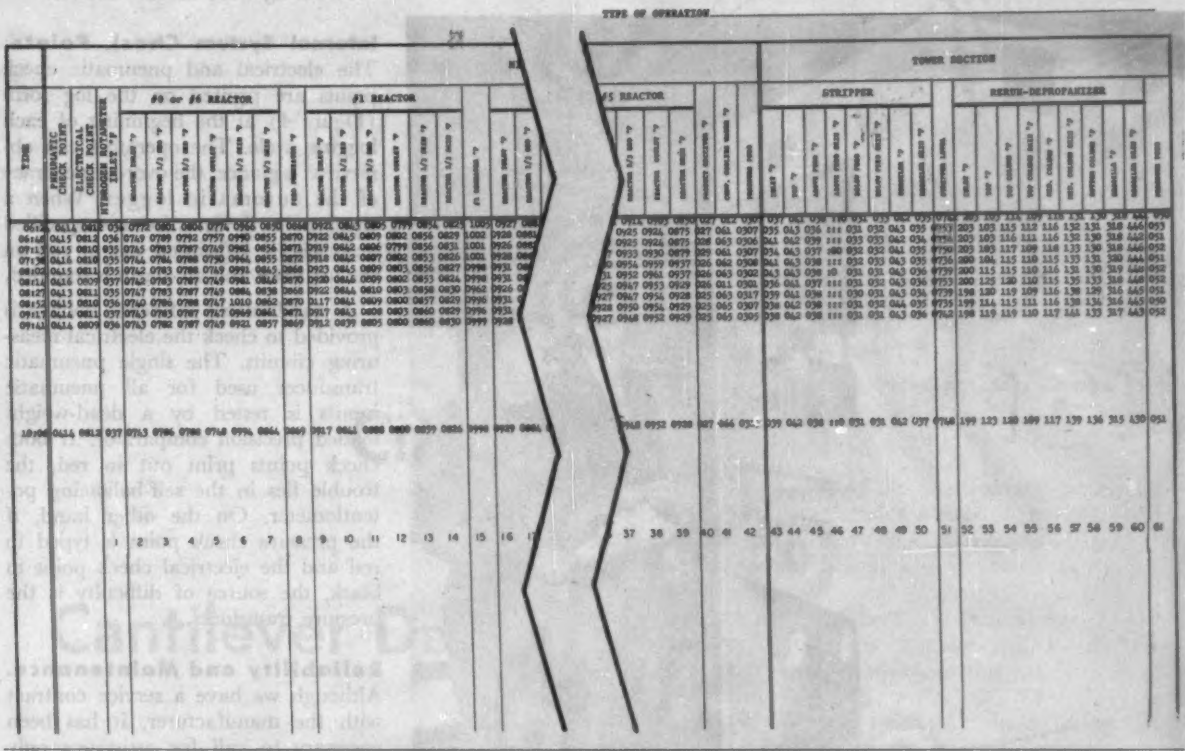


FIGURE 4—The readout interval can be varied from continuous to once per hour.

base which receives the electrical signals from the logger. The 26 x 14-inch log form allows a total of 300 characters per line and 70 lines per chart. Schematic flow diagrams of the pilot plant, similar to those in Figures 2 and 3, are located next to the typewriter in the dust-proof cabinet. Part of the maze of pipe, wire, valves, and gages that constitute the pilot plant also is visible in Figure 1.

Elements of Logger System. Figure 5 shows the logger cabinet. It houses all the elements of the logger system except the typewriter and primary sensing devices. It is located remotely, for convenience, on a different level in the building. The signals which are fed into this cabinet from the catalytic reforming unit comprise 58 primary electrical signals from thermocouples and 3 primary pneumatic signals (later converted to electrical).

The complex circuitry within the logger may be divided into four groups. Each does its part in sending the analog signal from the primary source in the pilot plant to a digital record on the typewriter. These groups are:

- Pneumatic-to-electrical signal converters
- Point selector system
- Analog-to-digital conversion system
- Digital dividing network.

The first group changes pneumatic signals to electrical form by means of a special comparator. All signals are converted with a single transducer. Since a single calibration suffices for all pneumatic inputs, there is a substantial reduction in calibration and maintenance time.

The point selector system connects the voltages to be measured in sequence to the analog-to-digital conversion unit. These may be either check voltages, thermocouple voltages, or voltages from the pneumatic-to-electrical signal converters. The point selector system also sends the output of the analog-to-digital converter through the digital dividing network to the typewriter. In addition, a digital clock is scanned at each readout so that the time of the logging cycle can be recorded.

In the analog-to-digital conversion system the analog shaft position of the self-balancing potentiometer represents the magnitude of the electric signal. The electro-mechanical system converts the shaft rotation of the potentiometer into contact closures suitable for operating the electric typewriter. A special null-balance detection circuit in the conversion system permits "read-when balanced" operation. This gives a faster cycle than a fixed-interval reading system.

The digital dividing network on the output of the conversion system provides a maximum accuracy for millivolt digitizing. This is done by insuring that the major portion of the self-balancing potentiometer's slidewire is used, regardless of range. Thus, the ranges 0 to 600 and 0 to 1200 will each employ full-scale potentiometer deflection while printing out true

FIGURE 5—The logger cabinet is located remotely for convenience. Here the authors are checking its operation.

value. Slidewire life is prolonged by distributing wear in this manner.

Internal System Check Points. The electrical and pneumatic check points are printed on the log form (Figure 4) at the beginning of each logging cycle. The operators can observe at a glance, the over-all accuracy of the automatic logger. When a check point deviates from its specified accuracy, it is printed out in red on the log sheet and an alarm is sounded.

A standardized reference voltage is provided to check the electrical measuring circuits. The single pneumatic transducer used for all pneumatic inputs is tested by a dead-weight loaded precision comparator. If both check points print out in red, the trouble lies in the self-balancing potentiometer. On the other hand, if the pressure check point is typed in red and the electrical check point in black, the source of difficulty is the pressure transducer.

Reliability and Maintenance. Although we have a service contract with the manufacturer, it has been necessary to call for assistance only four times in the first year of operation. With an average of 30 minutes per day of preventive maintenance, the logger was kept in operation 95% of the time. The analog-to-digital converter on the logger and a key function switch on the typewriter were the major causes of downtime.

In March of 1957, the analog-to-digital converter was replaced with one of better design. In June, the typewriter switch was repositioned to prevent interference with other parts and for easier maintenance. Since then the logging system has had a 100 percent service factor and preventive maintenance has been reduced to 30 minutes per week.

In appraising automatic logging for any given process, the data output requirement must be throughly studied to determine (1) whether or not automatic logging is functionally justifiable, and (2) if so, how much process information (number of points) and at what frequencies (read-out intervals) will really be useful. Only after such an analysis can the data handling capacity of automatic logging be fully—and economically—used. ##

About the Authors

Arendt

Savoy

John J. Arendt, senior engineer in the process and product development division, The Standard Oil Co. (Ohio), has had 16 years of experience in the instrument field. He worked five years for the Cleveland Switchboard Co. before joining Sohio's Cleveland refinery in 1941. In 1955 he assumed his present duties and organized the divisions first instrument group. Arendt is also the engineer in charge of pilot plant instruments, and is a member of the Instrument Society of America.

John Savoy is a senior engineer in the process and production development division, The Standard Oil Co. (Ohio), and is in charge of the catalytic reformer pilot plant. He joined Sohio in June, 1954, and was assigned to the economic section of the process engineering division. Here, he worked on long range planning and the manufacturing divisions capital budget. Savoy has been in the pilot plant section since November, 1955. He has a B.S. degree in chemical engineering from the University of South Carolina.

Short Cut to Circular Cantilever Design

What is the deformation and the strength characteristics of a circular cantilever loaded normal to the plane of curvature?

Complicated?

Use the tables and find a simple solution.

H. D. Tabakman
Brentwood, N. Y.

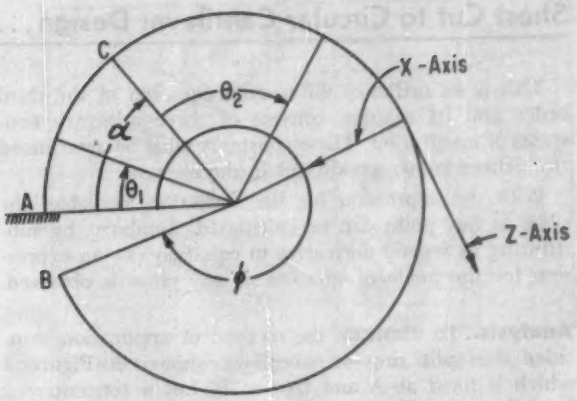


FIGURE 1—The load P is applied at C in a direction normal to the plane of the paper.

ENGINEERS ENGAGED in structural or mechanical design sometimes need a means of determining the deformation and strength characteristics of circular split rings, or cantilever beams, loaded normal to the plane of curvature.

The solution offered here is a general one. It is not restricted to the complete ring shown in Figure 1, nor to the form of loading, which in this case is that of a concentrated load 'P.'

By using equations (1) and (2), the deflection, slope and angle of twist at any point in the ring or curved circular cantilever can be determined regardless of the position of the applied load along it. This method is far superior to either the strain energy or virtual work principles. The later methods yield a deflection at one point only, for a particular position of 'P,' while the angle of twist has to be calculated separately.

Deflection Equation. Derivation of equations (1) and (2), which govern the deformation of curved bars loaded normal to the plane of curvature, is accomplished by expressing curvature and twist as functions of displacement and angular rotation. This is not unlike the process followed in deriving the deflection equation for curved bars loaded in plane. There exists, however, an important difference in that in the former, flexure is accompanied by torsion. This has an important effect on the deformation characteristics.

The differential equations referred to are:

$$\frac{M_\theta}{EI} = \frac{\beta}{R} - \frac{1}{R^2} \cdot \frac{d^2w}{d\theta^2} \quad \ldots\ldots\ldots\ldots \quad (1)$$

$$\frac{T_\theta}{KG} = \frac{1}{R}\frac{d\beta}{d\theta} + \frac{1}{R^2} \cdot \frac{dw}{d\theta} \quad \ldots\ldots\ldots\ldots \quad (2)$$

Differentiating (1) with respect to Θ and combining with (2), β is eliminated and a general differential equation (3) obtained is:

$$\frac{d^2w}{d\theta^2} + \frac{dw}{d\theta} = -R^2\left(\frac{1}{EI} \cdot \frac{dM_\theta}{d\theta} - \frac{1}{KG} \cdot T_\theta\right) \quad \ldots\ldots \quad (3)$$

If no bending or torsion operate, equation (3) assumes the form,

$$\frac{d^2w}{d\theta^2} + \frac{dw}{d\theta} = 0 \quad \ldots\ldots\ldots\ldots \quad (3.1)$$

Short Cut to Circular Cantilever Design . . .

This is an ordinary differential equation of the third order and its solution consists of three arbitrary constants of integration. These constants must be determined from three known conditions in the element.

With the expression for the deflection available, the slope at any point can be calculated. Similarly, by substituting its second derivative in equation (1) an expression for the angle of rotation at any point is obtained.

Analysis. To illustrate the method of application, consider the split ring or cantilever shown in Figure 1 which is fixed at A and free at B. Let a concentrated load P act at C, at an angular distance α from OA. The reactions at A are:

$$\text{Bending Moment } M_A = PR \sin \alpha$$

$$\text{Torsion } T_A = PR (\cos \alpha - 1)$$

$$\text{Shear } S_A = P$$

Considering length AC and signifying all values pertaining to it by suffix 1, the bending moment and torsion at angle Θ_1 from OA is:

$$M_{\Theta_1} = - PR \sin (\Theta_1 - \alpha)$$

$$T_{\Theta_1} = PR [\cos (\Theta_1 - \alpha) - 1]$$

and

$$\frac{dM_{\Theta_1}}{d\Theta_1} = - PR \cos (\Theta_1 - \alpha)$$

Substituting in equation (3):

$$\frac{d^2w_1}{d\Theta_1^2} + \frac{dw_1}{d\Theta_1} = \frac{PR^2}{EI}\left[\cos (\Theta - \alpha) + [\cos (\Theta - \alpha) - 1]\right] \quad . . . . . (4)$$

where

$$\psi = \frac{EI}{KG}$$

The solution of equation (4) is:

$$w_1 = A_1 + B_1 \cos \Theta_1 + C_1 \sin \Theta_1 - \frac{PR^2}{2EI}$$
$$\{\Theta_1 \cos (\Theta_1 - \alpha) + \psi [\Theta_1 \cos (\Theta_1 - \alpha) + 2\Theta_1]\} \quad . . . . (5)$$

The first and second derivatives of (5) are:

$$w_1' = - B_1 \sin \Theta_1 + C_1 \cos \Theta_1 - \frac{PR^2}{2EI}$$
$$\{\cos (\Theta_1 - \alpha) - \Theta_1 \sin (\Theta_1 - \alpha) + \psi [\cos (\Theta_1 - \alpha) - \Theta_1 \sin (\Theta_1 - \alpha) + 2]\}$$

$$w_1'' = - B_1 \cos \Theta_1 - C_1 \sin \Theta_1 - \frac{PR^2}{2EI}$$
$$\{-2 \sin (\Theta_1 - \alpha) - \Theta_1 \cos (\Theta_1 - \alpha) + \psi [-2 \sin (\Theta_1 - \alpha) - \Theta \cos (\Theta_1 - \alpha)]\}$$

Substituting in (1), the expression for the angular rotation at any point along AC is obtained:

$$\beta_1 = - \frac{B_1}{R} \cos \Theta_1 - \frac{C_1}{R} \sin \Theta_1 - \frac{PR^2}{2EI}$$
$$\{-\Theta_1 \cos (\Theta_1 - \alpha) + \psi [-2 \sin (\Theta_1 - \alpha) - \Theta_1 \cos (\Theta_1 - \alpha)]\}$$

The constants of integration A_1, B_1, C_1, are obtained from the end condition at A. These are:

$$\left.\begin{matrix} w_1 = 0 \\ w_1' = 0 \\ \beta_1 = 0 \end{matrix}\right\} \text{ at } \Theta_1 = 0$$

After suitable substitutions, the following values are obtained:

$$A_1 = \frac{PR^2}{EI} \psi \sin \alpha$$

$$B_1 = \frac{PR^2}{EI} \psi \sin \alpha$$

$$C_1 = \frac{PR^2}{2EI}\{\cos \alpha + \psi (2 + \cos \alpha)\}$$

Thus:

$$w_1 = - \frac{PR^2}{2EI}\{\Theta_1 \cos (\Theta_1 - \alpha) - \sin \Theta_1 \cos \alpha + \psi [\Theta_1 \cos (\Theta_1 - \alpha) + 2\Theta_1 + 2 \sin \alpha (\cos \Theta_1 - 1) - \sin \Theta_1 (2 + \cos \alpha)]\} \quad . . . (6)$$

$$\text{slope} = \frac{1}{R} \cdot \frac{dw_1}{d\Theta_1} = - \frac{PR^2}{2EI}$$
$$\{-\Theta_1 \sin (\Theta_1 - \alpha) + \sin \Theta_1 \sin \alpha + \psi [-\Theta_1 \sin (\Theta_1 - \alpha) - \sin \Theta_1 \sin \alpha + 2 (1 - \cos \Theta_1)]\} \quad . . . . . (7)$$

$$\beta_1 = - \frac{PR^2}{2EI}\{-\Theta_1 \cos (\Theta_1 - \alpha) + \sin \Theta_1 \cos \alpha + \psi [-\Theta_1 \cos (\Theta_1 - \alpha) + \sin \Theta_1 (2 - \cos \alpha)]\} \quad . . . . . (8)$$

In a similar way, the deflection at any point along CB, bearing in mind that no bending or torsion operate, is given by equation (3.1). The solution of this equation is:

$$w_2 = A_2 + B_2 \cos \Theta_2 + C_2 \sin \Theta_2$$

The first and second derivatives of w_2 are:

$$w_2' = - B_2 \sin \Theta_2 + C_2 \cos \Theta_2$$

$$w_2'' = - (B_2 \cos \Theta_2 + C_2 \sin \Theta_2)$$

Substituting in (1), the expression for the angular rotation at any point along CB is obtained:

$$\beta_2 = \frac{1}{R} w_2'' = - \frac{1}{R} (B_2 \cos \Theta_2 + C_2 \sin \Theta_2)$$

The constants of integration A_2, B_2, C_2, are obtained from the conditions of continuity at C. These are:

$$\left.\begin{matrix} w_2 = w_1 \\ w_2' = w_1' \\ \beta_2 = \beta_1 \end{matrix}\right\} \text{ at } \Theta_2 = 0 \text{ and } \Theta_1 = \alpha$$

On suitable substitution the following values are obtained:

$$A_2 = - \frac{PR^2}{2EI} \psi [2 (\alpha - \sin \alpha)]$$

$$B_2 = \frac{PR^2}{2EI}\left\{\frac{\sin 2\alpha}{2} - \alpha + \psi \left[2 \sin \alpha - \frac{\sin 2\alpha}{2} - \alpha\right]\right\}$$

$$C_2 = - \frac{PR^2}{2EI}\{\sin^2 \alpha + \psi [2 (1 - \cos \alpha) - \sin^2 \alpha]\}$$

Thus:

$$w_2 = - \frac{PR^2}{2EI}\left\{\left(\alpha - \frac{\sin 2\alpha}{2}\right)\cos \Theta_2 + \sin \Theta_2 \sin^2 \alpha + \psi \left[\left(\frac{\sin 2\alpha}{2} - 2 \sin \alpha + \alpha\right)\cos \Theta_2 + (2 - 2 \cos \alpha - \sin^2 \alpha) \sin \Theta_2 + 2 (\alpha - \sin \alpha)\right]\right\} \quad . . . . . (9)$$

$$\text{slope} = \frac{1}{R} \cdot \frac{dw_2}{d\Theta_2} = - \frac{PR^2}{2EI}\left\{\left(\frac{\sin 2\alpha}{2} - \alpha\right) \sin \Theta_2 + \sin^2 \alpha \cos \Theta_2 + \psi \left[\left(2 \sin \alpha - \frac{\sin 2\alpha}{2} - \alpha\right) \sin \Theta_2 +\right.\right.$$

$$\left[+\left(2\,(1-\cos\alpha)-\sin^2\alpha\right)\cos\Theta_2\right]\Big\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

$$\beta_2=-\frac{PR^2}{2EI}\left\{\left(\frac{\sin 2\alpha}{2}-\alpha\right)\cos\Theta_2-\sin^2\alpha\sin\Theta_2+\psi\right.$$
$$\left.\left[\left(2\sin\alpha-\frac{\sin 2\alpha}{2}-\alpha\right)\cos\Theta_2+\left(\sin^2\alpha+2\cos\alpha-2\right)\sin\Theta_2\right]\right\}$$
$$. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

The separate expressions for deflection, slope and angular rotation obtained for lengths AC, and CB, may be written in the general form of:

$$w=-\frac{PR^3}{2EI}(a_0+b_0\psi) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

$$\frac{1}{R}\,\frac{dw}{d\Theta}=-\frac{PR^3}{2EI}(a_1+b_1\psi) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

$$\beta=-\frac{PR^3}{2EI}(a_2+b_2\psi) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

It should be observed that all figures in Table 1 to the left of the heavy dividing line are those pertaining to length AC, and those to the right to CB. This has no special significance but is remarked upon here to avoid confusion.

Design Notes. It will be observed that the expressions for deflection, slope and angular rotation, consist of two distinct factors 'a' and 'b.' These have a very definite meaning. The 'a' factor signifies the contribution of flexure to deflection, slope or angular rotation, whereas the coefficient of ψ, namely 'b' indicates the contribution of torsion. This is a fortunate division for it affords a considerable degree of freedom in controlling deformations to desired limits coupling this with an efficient cross section for the structural member.

The tabular values given here should therefore be used in the preliminary design stage rather than as a mere check after the design had been finalized.

The torsional rigidity defined by KG merits close attention. Although values of 'b' may be smaller than those of 'a,' the torsional effect may never-the-less prove greater than that due to flexure. This is particularly true in the case of open cross-sections. Here the value of the torsional rigidity may be a mere fraction of the flexural rigidity resulting in a high value for ψ, and an unduly large deformation may be the result.

Other Forms of Loading. The method of solution indicated in this paper is applicable to any form of loading acting normal to the plane of curvature. In all cases, the general deflection equation (3), must be solved. The resulting expressions for deflection, slope and angular rotation will be in the form of equations (11), (12), and (13), but factors 'a' and 'b' must be calculated for individual loading cases.

Superposition. Provided the structure behaves elastically, the principle of superposition is fully applicable. Thus, a difficult combination of applied loads can be resolved, solved individually, and corresponding values added algebraically.

If the structure analyzed in this paper is simply supported somewhere along its length in addition to being held at 'A,' the coefficients given in the tables may still be put to good use. All that need be done is to determine the reaction at the support, which incidentally, is statically indeterminate. Once this is accomplished, the deflection, slope and angular rotation may be calculated by using the coefficients given in the tables with the signs reversed. The effective values are then arrived at by superposition. It may be concluded that the present tables are applicable in evaluating the effect of one or more simple supports regardless of the form of the applied loading end 'A' is rigidly held.

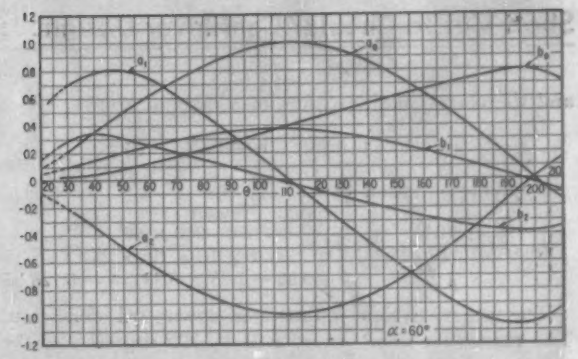


FIGURE 2—Curves giving coefficients a_0, b_0, a_1, b_1, a_2, b_2.

Example. To illustrate the example of data given in the tables, consider the circular cantilever loaded and supported in a manner shown in Figure 1. Given:

Load P = 200 lbs.

Radius R = 5.0 ft.

Material—Aluminum Alloy

$E = 10 \times 10^6$ lbs./in.^{2} $\quad G = 4 \times 10^6$ lbs./in.^{2}

$\alpha = 60$ degrees $\quad \psi = 210$ degrees

The cross-section is circular with:

r = 4.0 in. $\quad$ t = 0.125 in.

The following information is required:

1. Maximum Deflection, Slope and Angular Rotation and their respective location.
2. Deflection slope and angular rotation at the free end.
3. Deflection slope and angular rotation at the point of application of the load.

General values required for the following calculations are:

$$I=\pi r^3 t=\pi\times 4^3\times 0.125=25.12 \text{ in.}^4$$

$$K=2I=50.25 \text{ in.}^4$$

$$\psi=\frac{EI}{KG}=1.25$$

To obtain the relevant values of: a_0, b_0, a_1, b_1, a_2, b_2, it is best to plot these against Θ as shown in Figure 2. By applying equations (12), (13) and (14) the above requirements may be calculated.

The maximum deflection occurs at $\Theta = 110$ degrees

and the corresponding values of a_0 and b_0 are:

$$a_0 = 0.98 \qquad b_0 = 0.39$$

Applying equation (12):

$$w_{max} = -\frac{PR^3}{2EI}(a_0 + b_0\psi) = -\frac{200 \times 60^3}{2 \times 10 \times 10^6 \times 25.12}$$
$$(0.98 + 1.25 \times 0.39) = -0.128 \text{ in.}$$

The negative sign indicates a downward deflection. The maximum slope occurs at $\Theta = 195$ degrees and the corresponding values of a_1 and b_1 are:

$$a_1 = -1.05 \qquad b_1 = 0$$

Applying equation (13):

$$\text{Maximum slope} = -\frac{PR^2}{2EI}(a_1 + b_1\psi) = -\frac{200 \times 60^2}{2 \times 10 \times 10^6 \times 25.12}$$
$$(-1.05 + 0) = 0.0015 \text{ radians}$$

The maximum angular rotation occurs at $\Theta = 110$ degrees, and the corresponding values of a_2 and b_2 are:

$$a_2 = -0.985 \qquad b_2 = -0.03$$

Applying equation (14):

$$\beta_{max} = -\frac{PR^2}{2EI}(a_2 + b_2\psi) = -\frac{200 \times 60^2}{2 \times 10 \times 10^6 \times 25.12}$$
$$(-0.985 - 1.25 \times 0.03) = 0.00146 \text{ radians}$$

The positive sign indicates a clock-wise rotation when viewed in the direction of the Z axis.

The deflection, slope and angular rotation at the free end, and the point of application of the load (forming requirements 2 and 3 in this example) are calculated in a manner identical to that just described.

NOMENCLATURE

- M_{θ_1} — Bending moment about the X-axis at an angle Θ_1, lb.-in.
- T_{θ_1} — Torsion about the Z-axis at an angle Θ_1, lb.-in.
- P — Concentrated load, lb.
- R — Radius of ring or cantilever, in.
- I — Moment of inertia about the X-axis, in.^{4}
- K — Form factor relevant to torsion, depending upon shape of cross-section, in.^{4}
- E — Modulus of Elasticity, lb./in.^{2}
- G — Modulus of Rigidity, lb./in.^{2}
- r — Radius of cross-section, in.
- t — Wall thickness, in.
- a_0, a_1, a_2 — Flexure coefficients pertaining to deflection, slope and angular rotation respectively
- b_0, b_1, b_2 — Torsion coefficients pertaining to deflection, slope and angular rotation respectively
- ϕ — Angle defining length of ring or cantilever measured from OA, degrees
- α — Angle defining location of the applied load, degrees
- Θ — Any angle measured from OA given in tables, degrees
- w — Deflection, in.
- $\frac{w'}{R}$ — Slope, radians
- β — Angular rotation, radians
- Θ_1 — Any angle measured from OA pertaining to length AC
- Θ_2 — Any angle measured from OC pertaining to length CB
- ψ — $\frac{EI}{KG}$, non dimensional

TABLE 1

Coefficients of Deflection, Slope and Angular Rotation.

Bold Face Figures Denote a Negative Value.

	Θ	30°	60°	90°	180°	270°	360°
α = 30°	a_0	0.092	0.204	0.262	0.045	**0.262**	**0.045**
	b_0	0.004	0.018	0.041	0.093	0.053	0.0007
	a_1	0.250	0.170	0.045	**0.262**	**0.045**	0.262
	b_1	0.018	0.0373	0.046	0.0061	**0.046**	**0.0061**
	a_2	**0.092**	**0.204**	**0.262**	**0.045**	0.262	0.045
	b_2	0.0434	0.0265	0.0061	**0.0465**	**0.0061**	0.046
α = 60°	a_0	0.203	0.62	0.905	0.332	**0.90**	**0.332**
	b_0	0.020	0.125	0.269	0.740	0.455	0.020
	a_1	0.694	0.74	0.335	**0.989**	**0.335**	0.905
	b_1	0.096	0.25	0.342	0.093	**0.342**	**0.093**
	a_2	**0.203**	**0.620**	**0.905**	**0.332**	0.90	0.332
	b_2	0.295	0.247	0.093	**0.342**	**0.093**	0.342
α = 90°	a_0	0.262	0.910	1.570	1.0	**1.570**	**1.0**
	b_0	0.0408	0.272	0.710	2.14	1.57	0.140
	a_1	0.955	1.389	1.0	**1.57**	**1.0**	1.57
	b_1	0.223	0.657	1.0	0.430	**1.0**	**0.430**
	a_2	**0.262**	**0.910**	**1.57**	**1.0**	1.570	1.0
	b_2	0.738	0.822	0.430	**1.0**	**0.43**	1.0
α = 180°	a_0	0.045	0.341	1.0	3.14	0	**3.14**
	b_0	0.092	0.705	2.140	9.42	10.28	3.14
	a_1	0.262	0.910	1.570	0	**3.14**	0
	b_1	0.529	1.910	3.570	4.0	**3.14**	**4.0**
	a_2	**0.045**	**0.341**	**1.0**	**3.14**	0	3.14
	b_2	1.955	3.121	3.0	**3.14**	**4.0**	3.14
α = 270°	a_0	**2.620**	**0.910**	**1.57**	0	4.720	1.0
	b_0	0.055	0.452	1.57	10.280	18.140	12.450
	a_1	**0.955**	**1.389**	**1.0**	3.14	1.0	**4.720**
	b_1	0.313	1.342	3.0	7.140	1.0	**6.725**
	a_2	0.262	0.910	1.570	0	**4.720**	**1.0**
	b_2	1.266	2.642	3.570	0	**6.725**	**1.0**
α = 360°	a_0	**0.045**	**0.341**	**1.0**	**3.14**	1.0	6.28
	b_0	0.0007	0.020	0.140	3.14	12.420	18.840
	a_1	**0.2618**	**0.910**	**1.57**	0	4.720	0
	b_1	0.0062	0.090	0.430	4.00	6.720	0
	a_2	0.045	0.341	1.0	3.140	**1.0**	**6.28**
	b_2	0.045	0.341	1.0	3.14	**1.0**	**6.28**

About the Author

H. D. Tabakman is a consulting elastician in New York City. He has had 20 years experience, mainly in England, in the analysis of problems in elasticity pertaining to aircraft, basic helicopter research, jet engines, guided missiles, shells, plates, testing and photo-elasticity. Tabakman is an engineering graduate of Northampton Engineering College and London University. Prior to becoming a consultant, he spent two years as chief elastician in the technical branch of the Israeli Army, and one year as director of engineering of El-Al Israel Airlines. lines.

FIGURE 1—Backing up shaft prevents bearing damage.

PM Cuts Motor Maintenance Costs

The preventive maintenance that your motors get today will be the maintenance cost cutter of tomorrow.

J. W. Samzelius and R. F. Woll, Westinghouse Electric Corporation, Buffalo, New York

THE TRUE MEASURE of any industrial maintenance program is its effectiveness in preventing trouble. This is particularly true for induction motors because of their basic relationship to industrial production.

To forestall trouble, a program of preventive maintenance must obviously be built around a systematic and regular check of parts that are susceptible to deterioration and wear.

DRIVE MOUNTING PROCEDURES

Gear Drives. When a motor is geared directly to the load, a common bedplate is usually employed and the motor dowelled in place to retain proper gear mesh. If spiral or helical gears are employed, the pinion must not cause excessive thrust load on the motor bearings. Ball bearings can usually sustain such axial thrust but sleeve bearings are apt to become overloaded.

Direct or Coupled Drives. For these drives, the motor and the driven machine are also mounted on a common bedplate and dowelled in place to retain their precise alignment. Flexible couplings, which permit a reasonable amount of misalignment, are often employed for the connection but unless the shafts are closely in line, vibration and fatigue failures may result. It should be noted that pulleys, pinions or couplings must not be mounted by striking heavy blows unless precautions are taken to prevent reactions on the bearings. To protect the bearings from such forces the shaft must be adequately backed up at the opposite end, Figure 1.

Electrical Connections. When making electrical connections, it is important to make sure that the voltage, frequency, and phases of the power supply agree with the nameplate rating of the motor. Although most motors will operate satisfactorily over a 10 percent variation in voltage or a 5 percent variation in frequency, their performance may not equal that established for operation at normal nameplate rating.

Motor lead connections should be made in accordance with the connection plate. A suitable switch and suitable overload protection are necessary for connection to the power supply and all wiring and fusing should observe the National Electric Code and local requirements.

When the motor conduit box is not tapped to receive rigid conduit, and the conduit entry is to be from above, the recommended method of connecting conduit is as shown in Figure 2. Where conditions warrant, the same method may be applied to conduit entry from the sides. When the motor is mounted on slide rails for belt adjustments, flexible conduit should be used.

After connections are made, the motor should be operated without load to check the connections and direction of rotation. (To change the direction of rotation on three-phase machines, interchange any two line leads; to change the direction of rotation on two-phase motors, interchange the line leads of either phase.) Since large high-speed motors, and particularly those of the totally enclosed, fan-cooled

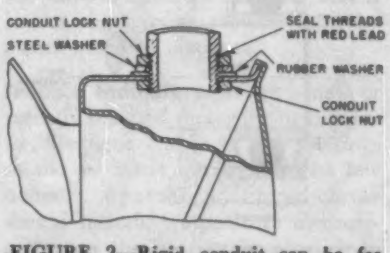


FIGURE 2—Rigid conduit can be fastened to untapped boxes with lock nuts.

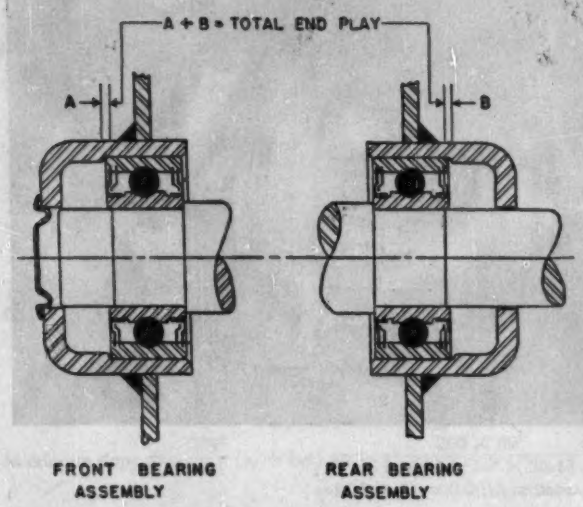


FIGURE 3—Using sealed bearings with end play allows either bearing to take the thrust.

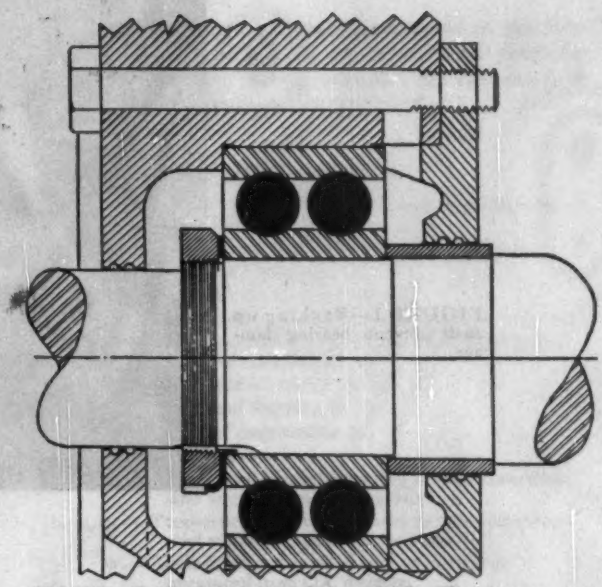


FIGURE 4—Retaining ring locks extension bearing to shaft which prevents axial movement of the rotor.

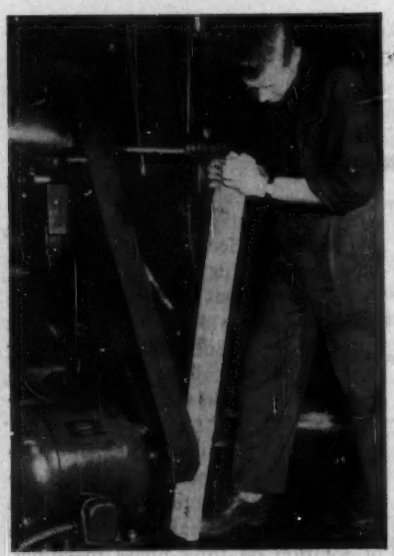


FIGURE 5—Timber and toe combine to test for proper end play.

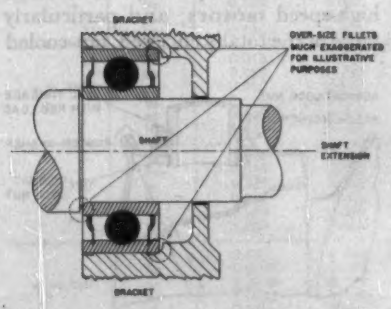


FIGURE 6—Bearing-locating fillets may restrict end play.

type have unidirectional fans, it is important that the direction of rotation of the motor and the driven equipment be properly matched.

Inspection Program. Although modern ball-bearing motors require very little attention in service, a thorough inspection program of the entire motor should be carried out at intervals determined by the conditions of operation and the severity of service. The findings resulting from inspections should be recorded for comparison with similar findings at earlier or later inspections. This comparison calls attention to progressive deterioration in any part. Complete records of deterioration or wear will be very helpful in planning the number of renewal parts to be carried in stock for a given number of units.

Routine servicing operations, such as regular oiling or greasing need not be recorded but the person performing these operations should be instructed to observe and report conditions that may prove significant. He should, for example, check abnormal noises to determine their source and cause. When servicing the motor he should look for above-normal temperatures, as evidenced by the feel of the frame or by the characteristic odor of overheated insulation. Excessive vibration may also be detected with the hand.

The oiler should also be instructed to wipe up any oil that is spilled during oiling; this will make it easier to detect slow and continuous leaks through bearing seals or oil fittings. Cleanliness in general should be stressed since an accumulation of dust and dirt around bearings and ventilation openings may cause bearing and insulation failures.

Motors With Ball Bearings. Grease-lubricated ball or roller bearings are the types most commonly applied to modern industrial motors. One reason for this preference is the simple and infrequent lubrication schedule that may be employed.

Since the amount of grease required by these bearing types is very small, and an excess of grease is always wasteful and at times harmful, a number of motor manufacturers prefer to install sealed bearings. Once given a lifetime charge of slow-aging or stabilized grease at the time of assembly, these bearings need not be regreased.

Sealed bearings are available only as deep-groove, single-row radial bearings (Conrad type) and only through the 315 size. The bearings are made in standard double-row width and are thus physically interchangeable with standard double-row bearings. In high speed applications and in vertical motors subject to heavy thrust, oil-lubricated ball bearings of the deep groove or angular contact type are usually furnished.

Since the major differences between various types of antifriction bearings applied in electric motors are in mounting or provisions for lubrication, most troubles and remedies dis-

cussed here apply to all types of anti-friction bearings.

Bearing Mountings. The simplest arrangement for bearing mounting results when pre-lubricated and sealed bearings are used in combination with a liberal end play for the rotor, Figure 3.

In this mounting, either bearing may take thrust. Thrust toward the motor is taken by the bearing at left, thrust away from the motor is taken by the bearing at right. The bearing housings can be extremely simple since the grease is retained inside the bearing and no provision is necessary for adding grease.

In a variation of this design, a preloading spring in the form of a wavy washer is pressed against the end of the outer race of the front end bearing. The purpose of the spring is to put both bearings under a slight axial load and thereby reduce the noise typical of loosely-fitted bearings. Since loose bearings adapt themselves more readily to dimensional changes from heat, the loose bearing held in a steady position by a spring, is a definite aid in all high speed applications.

For greasable bearings, the same type of mounting can be used although the housing is more complicated, since it must retain grease and prevent entry of dirt.

The housing must also be provided with grease fittings and a drain for used grease. Some designs have sump space for the collection of the grease leaving the bearing. Such sumps must be drained or emptied at suitable intervals. Sometimes, a grease pressure control is incorporated in the filling plug for protection against overfilling.

Where axial movements of the rotor are not permissible, the shaft extension bearing can be locked to the shaft by a locking nut or a retaining ring and the outer race clamped in the housing by extending the nose of the inner cap to bear on the side of the outer race, Figure 4. Since the opposite bearing must yield freely to all axial forces produced by shaft expansion it is not subjected to axial thrust.

End Play. Freedom for the shaft to expand with changes in temperature is extremely important for proper running performance of the bearings, regardless of the bearing type involved. This is particularly evident for sleeve bearings, since the shaft is often seen moving from side to side.

For ball bearings, end play is just as important, but this is not always obvious since the rotor may not move axially, even when both bearing are free to move. If one bearing is locked, the other must yield freely to any dimensional changes. Every motor should be checked for minimum safe end play before it is put in operation.

Minimum safe end play for any motor can be estimated by allowing 0.005 inch for every 12 inches of shaft between the bearings. In case of a floating rotor, the end play can be measured by pushing the rotor all the way first to one side and then to the other. Since this may require more force than can be exerted with the bare hands, a piece of timber can be used as a lever for moving the rotor, Figure 5. Blows on the shaft with a mallet should be avoided since this may damage the bearings or the center of the shaft.

Sometimes, it is necessary to limit the end play to less than the standard amount (Proper functioning of the centrifugal switch in single-phase motors may be such a reason). This can be done by inserting washer shims behind one bearing. If such washers are found in the bearing housing, it is essential to replace them as found in the final assembly. Where one bearing is locked to the housing, the locking bolts must be loosened to permit the rotor to move axially. By loosening the bolts only slightly more than is necessary for the end play desired and by tapping the bolt heads back, the inner bearing cap will release the bearing for the test. The cap should always remain in engagement with the housing bore; when one is satisfied that the end play is right, the bolts are again drawn tight.

Insufficient End Play. If the brackets are hard to remove from the bearings, the difficulty may be due to several causes: (a) the housing bore may be too small; (b) corrosion or rust may bind the bearing; or (c) the bearing housing may be distorted and thus be pinching the bearing at opposite points.

In (a) or (b), the bore may be relieved or cleaned to produce a sliding fit with the bearing. In case of warpage or an oval bore, (c), the bracket or bearing housing should be replaced.

If the brackets come off easily, after they are freed from the frame, a lack of end play is probably caused by incorrect machining of the shaft, the brackets, or the frame. Incorrectly machined parts may result in a deficiency in end play or in misalignment and binding. The most serious type of thrust loading on the bearings appears if the bearings in the completed assembly are solid against the shoulders of both end brackets (The bearings might then even become preloaded when bolting the brackets to the frame). This condition may produce very high thrust loading on both bearings, especially after heat causes the shaft to expand. However, such extreme conditions are very rare. Routine testing by the manufacturer is certain to reveal such a condition before shipment.

If the fillet radii of the shoulders locating the bearing on the shaft and/or the fillet radii of the housing shoulders limiting the total end play of the rotor in the assembly are too large, Figure 6, the bearings may locate against the fillets rather than against the shoulders proper, causing a condition similar to the one just discussed. A visual inspection of the fillets and shoulders should reveal whether the bearings are seated properly; if they are not, the faulty fillets must be corrected.

If the bore of the bracket is not true with the face of the rim or if the ends of the frame are not parallel, the bearing housings will not be in line after the brackets are bolted up with the frame and the bearings may then bind in the housings. Any misalignment betwen the bearings tends to lock the bearings in the bracket bore and thus the check of axial freedom (end play) is a valuable aid in establishing approximate alignment. After misalignment and binding is established, a satisfactory remedy must be found. If, for example, it is found that the bracket rim of one bracket is running out with the bore, it can be trued up. Since this will shorten the bracket, the end play may be reduced to an unsafe value and it may be necessary to move the shoulder, which locates the bearing on the shaft, by a corresponding amount.

Trouble Indicators. When a new or recently repaired motor is put in service, frequent checks of the bearings should be made during the first few hours of operation. These checks should include temperature measurements on the bearing housing or in the oil reservoir. After two to three

hours of continuous running, the bearing temperature may be expected to level off at a temperature ten to twenty degrees C above the ambient temperature. The total temperature of the bearing is ordinarily not important since it depends largely on ambient conditions. It must not, of course, be so high that the bearing materials are damaged or the lubricant suffers from sludging and rapid deterioration that occurs with increased temperature. On the other hand, the belief that a bearing is too hot when the housing is too hot to be touched with the hand is not a sure indication of bearing trouble.

At infrequent intervals, all bearings in standard applications should be checked by thermometer and their temperature rise recorded. A replacement bearing can then be allowed an equivalent rise before corrective action is taken. If a certain bearing normally operates at only 10 C above the ambient temperature, and a replacement bearing runs at 20 degrees above ambient, the replacement should be viewed with suspicion, even though total temperature may not be alarming. A temperature limit of 85 C applies both to oil-lubricated and grease-lubricated bearings of both sleeve bearing and antifriction types in all normal temperature applications.

High temperature in ball or roller bearings may be caused by several factors; among these are: (a) lack of lubrication; (b) excessive lubrication, resulting in too much agitation in the lubricant; (c) insufficient end play, resulting in high thrust load on the bearing; and (d) if normal expansion of the bearing is hampered by the housing. Condition (d) may be caused by an undersized housing bore or caused by rapid cooling of the housing which prevents the housing from expanding at the rate at which the bearing is expanding.

For these causes of high bearing temperature, various remedies may be applied. If, as in (a), the bearing lacks lubrication, the obvious procedure is to provide lubricants according to given instructions. If a lubrication schedule has been followed, it should be evident whether lack of lubrication is a factor. The noise emitted by a bearing lacking lubrication is usually harsh and grinding.

Excessive lubrication, as in (b), is a common reason for high bearing temperature and may be expected to cause the temperature to rise shortly after the bearing has been greased. It is significant that grease-lubricated ball bearings react in the opposite way to oil-lubricated sleeve bearings when subjected to excessive lubrication.

An excess of oil in the sleeve bearing is never the cause of heat generation; oil not used for actual lubrication will assist in carrying away heat generated in the bearing. On the other hand, an excess of grease or oil in ball bearings is a direct cause of heat generation in the bearing. It is often the cause for serious trouble. (Noise emitted by an overgreased bearing is usually of a whining or squealing character.)

The cure for an overgreased bearing is simply to relieve the bearing of its excess grease. In many instances, this can be done while the motor is running, merely by removing the drain plug provided in the bottom of the housing. At times, it may be necessary to aid the grease to drain out to speed up cooling.

Lack of end play—and the consequent heavy thrust load on the bearings due to normal expansion of the shaft—is a serious reason for overheated bearings. Both bearings are affected by the thrust, and the bearing with the least capacity in the direction of thrust will be first to fail. One simple but strictly temporary remedy, which can be applied without stopping the motor, is to loosen the bracket bolts at either end, being careful not to disengage the rabbet fit in the frame. An axial separation of only a few mils between the bracket and frame may relieve the thrust load and thereby reduce the temperature to a safe value. At the very first opportunity the reason for the binding must be removed and the loosened bracket bolted tight.

If the bearing housing restrains the bearing from expanding radially when heat is generated, the bearing may fail because of increased radial load. Greater internal looseness in the bearing tends to minimize such loading, hence the reason for going to looser bearing with preloading springs as mentioned earlier.

Increased pressure between the outer race and the housing, which is the result of uneven expansion in the two members, may also prevent the bearing from sliding axially when the shaft is expanding in length. This condition (same as outlined under c) may cause the bearings to fail in thrust.

From this, it is obvious that attempts to cool a hot ball bearing by cooling its housing—which may be done successfully for a hot sleeve bearing—are likely to be disappointing and will probably speed ultimate failure. Antifriction bearings may be cooled safely by removing heat from the shaft; this may be done by directing an air stream against the shaft or against the couplings or pulleys adjacent to the bearing.

Diagnosing Troubles. The experienced engineer can often determine the reasons for trouble by examining the damaged bearing, but material defects, whether in the bearing proper or in the lubricant, can usually be determined only in the laboratory. Conditions such as misalignment, overload, damage in mounting, or damage from vibration or from electric current leave typical markings in the raceways that are easily recognized. To diagnose these troubles, it is essential that the bearing to be examined not be a complete failure; if so, all evidence of the cause is probably destroyed. Likewise, the bearing to be examined must be removed from the shaft without additional damage to the raceways.

Although it is unlikley that a damaged bearing can be restored to service, an examination is well worth the expense. By finding out what caused the bearing to fail, we can usually avoid repetition of the trouble. Since lack of grease, overgreasing, unsuitable grease, and dirt introduced with the grease are factors causing trouble, it is important to differentiate between "ordinary bearings" (bearings requiring periodic lubrication, which are subject to these factors) and "sealed bearings," from which these hazards are practically eliminated.

Some of the more typical indications or markings resulting from various causes are described below. More detailed information, including excellent picture reproductions of bearing damage is published by The American Society of Lubrication Engineers, 84 East Randolph Street, Chicago, Ill.

A bearing failure caused by "lack of grease" will probably show dis-

coloration because of heat. The heat may also have caused the small amount of grease contained in the bearing to burn and carbonize. This may be found as a black dry powder in protected places of the bearing. Such a bearing usually shows wear and will feel rough and loose in turning. It may also be very noisy prior to failure.

Overgreasing may also cause the bearing to run hot and fail. In this case, one may find an oversupply of grease in the bearing. The grease next to the balls is probably mixed with carbonized grease to form a black, semisolid dough. Possibly, grease will also be found inside the motor where it may have damaged the insulation. Moreover, the bearing will probably be discolored from heat.

Bearing failures entirely caused by overload (not caused by misalignment or lack of end play) are rare, since the useful life of a bearing under known load conditions can be predicted quite accurately. In belted applications, the load is not definitely known and is sometimes greatly in excess of what is estimated as normal. Such conditions are usually due to poorly designed belt drives or careless belt adjustment and will result in unsatisfactory belt life as well as in bearing trouble. In coupled applications, the bearing loads are normally very light and the useful life of the bearings is ordinarily very long. However, if the line-up between shafts is poor, vibration and side load imposed by the misalignment may reduce bearing life to only a fraction of its expected value. Also, if the spacing between the coupled machines is not made properly, thrust loading on the bearings may cause unexpected failures. Typical signs of overload are fatigue pitting or flaking in the area subjected to the heaviest load. If such pitting appears in the center of the ball track and is distributed all around, it can be concluded the bearing has been overloaded radially. If the pitting appears only in two diametrically opposite locations, the indication is that the bearing is squeezed oval by an oval housing. If the pitting is offset to one side, the fatigue is caused by thrust load and if the pitting shows weaving from side to side, the bearing may be misaligned.

Hard particles or dirt may cause pitting in the raceways, but the marks are apt to be isolated and located irregularly. The edges of the craters are usually smooth and flattened in contrast to the edges of fatigue pits which are jagged and sharp. Damage from dirt is perhaps more common in the outer raceway, since centrifugal force tends to force heavy particles in this direction. Fatigue damage is more likely to show up first in the inner race since the balls pass a given spot more frequently in the inside track. A bearing containing hard particles will usually emit a variation of noises depending upon shifts in the location of the particles. When turned over slowly by hand, the bearing will feel rough and show a tendency to stick.

Infrequently, bearings may suffer severe damage from abnormal external causes. One such cause is the circulation of an electric current through the bearing; another is vibration in the foundation during prolonged shutdowns or in stand-by machines. Instances of damage from both causes appear somewhat similar in that transverse dents or grooves may appear in the raceways. The grooves from electric discharges have dull surfaces and are distributed all around, resembling a miniature washboard. Dents resulting from vibration at standstill are spaced at the exact spacing of the rolling elements, primarily on the load side, and have shiny and polished surfaces.

Electric discharge may be due to voltage generated in the machine by an unbalanced condition in the magnetic field (such unbalance may be caused by a shortened coil). Corrections may involve rewinding the machine or simply discharging static voltage to ground, or bypassing the bearings with a shunt from a collector on the shaft to ground. In pedestal-type bearings, it may be practical to insulate the bearings from ground.

An unbalanced load on the shaft can produce very destructive vibration forces which must be eliminated by proper balance of all rotating parts. The rotor is balanced on the shaft before the machine leaves the factory but pulleys or fans must also be in balance. Bearing damage caused by vibration is illustrated in Figure 7.

Replacing Failed Bearings. When a bearing has failed or shows advance indications of early failure, it must be replaced with a bearing of the same type as the original. Replacement bearings are preferably obtained through the manufacturer of the motor. Since commonly used bearings are standardized, interchangeable replacement bearings can usually be obtained locally.

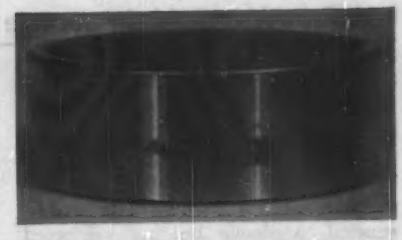


FIGURE 7—A first sign of damage to bearings by vibration is discoloration and shallow pitting around the outside of the outer race.

When mounting the bearing on the shaft, pressure or blows must not be exerted on any part of the bearing except on the side of the inner race, using a squarely cut-off tube of slightly larger bore than the shaft and slightly smaller O.D. than the inner race. If the bearing is greasable it must be protected from dirt during installation. Grease of suitable type should be worked into the bearing from both sides using a clean wood paddle or clean hands. An additional quantity of grease shall be put into the housing next to the bearing but only about one-fourth or one-third of the housing space shall be filled in at time of assembly.

Sleeve Bearings. Instructions for maintenance of sleeve bearings may be considerably simpler than instructions for ball bearings, even though the time spent for maintenance itself is ordinarily much greater. Proper functioning of the sleeve bearing depends entirely upon the existence of an oil film between the journal and the bearing. The common method for supplying oil to the point of entry in the bearing is by an oil ring which dips into a reservoir of oil below the bearing and is rotated by the journal. If the ring should slow down or stop, or if the oil falls below a certain level, the oil supply will diminish and the bearing will probably fail.

At starting, the journal is carried directly by the bearing, without the benefit of an oil film. The number of revolutions required to establish the oil film depends on a number of factors. Among these are friction between the ring and the journal; drag of the oil on the submerged part of the ring; inertia of the ring; physical dimensions of the ring; the acceleration and final speed of the journal;

and the speed at which the oil flows through the bearing.

With these factors to be considered, it is understandable that there may be considerable variations in the wear and useful life of the bearing. In general, a sleeve bearing subjected to frequent starts is more susceptible to wear than a bearing running at uniform speed for long periods.

For sleeve bearings, it is important to use oil of proper viscosity and to give special attention to the oil ring if the oil is very cold when the motor is started. The oil must, of course, be maintained at a proper level, although this level may change between running and stationary conditions. Whenever the oil level is checked, proper functioning of the oil ring should also be checked.

When bearings are replaced, the oil ring should be examined for roundness. If worn or polished spots appear on the interior surface, it should be replaced. Proper functioning of the oil ring is so important that extreme care should be taken in checking and handling the ring when assembling the bearing.

Since sleeve bearings have very little thrust capacity, they must not be applied to a thrust load. Many coupled applications—not ordinarily considered as thrust loads—may produce thrust loading because of characteristics of the coupling. Gear and pin-type couplings with large end play between driving and driven elements may permit these elements to shift their relative position under the influence of vibration or other secondary forces that appear during idling or shutdown. When the coupling is transmitting full torque, friction between its driving and driven elements practically locks the coupling solid; if locked in an unfavorable position, thrust of considerable magnitude may develop. To ensure that such thrust loading does not develop, the coupling should be one with limited end play; that is, its end play should be only a fraction of the end play in the motor. For similar reasons, slip clutches and friction drives which are not restricted to very small axial adjustments may produce excessive thrust forces.

Sleeve bearings are usually provided with greater end play than ball bearings and since the shaft (rotor) is free to move axially, the end play is easily checked. This greater end play is important since axial magnetic forces on the rotor may balance out by a relatively small displacement of the rotor; thus, thrust on the bearings caused by magnetic forces may be avoided.

End Thrust. Unless thrust loads from the magnetic forces can be proven to have caused bearing failure, a tendency for the rotor to run against the bearing shoulder should not cause alarm since the forces usually are small and well within the capacity of the bearing.

On the other hand, "external" forces, such as the force from a misaligned belt drive or spiral or bevel gears, are usually of greater magnitude and must not be permitted. If moderate and unavoidable thrust causes bearing failure, an improvement can often be made by providing more oil for the thrust face of the bearing. This can usually be accomplished by extending the oil grooves to the thrust face and even across the thrust face. Restricting the oil drainage holes near the thrust face may also provide more oil where it is needed. The thrust shoulder of the shaft should also be smooth and polished to reduce friction and wear.

When steps are taken to provide more oil to the bearing thrust face, it becomes more difficult to prevent oil leakage to the interior of the motor. Therefore, the proper way to eliminate bearing trouble, caused by thrust, is to eliminate the thrust itself.

Felt seals at the ends of the bearing are not intended to prevent oil from flowing from the bearing but to prevent air currents from carrying oil mist into the motor. By preventing air circulation through the bearing, air-borne dust is also excluded. Air vents in the bearing housing, which are commonly provided in modern designs, equalize the pressure and thereby prevent air from passing through the bearings.

Sleeve bearings carrying heavy overhung loads (belt loads, for example) are often subject to load concentration at the outer end because of shaft deflection. Babbitt-lined bearings probably adjust more readily to shaft deflection than do bearings of harder materials but shaft deflection (bell mouthing) is a common reason for failure. If worn spots appear at the end of the bearing in the direction of the load, scraping the worn spot will distribute the load over a larger area. The belt load may also be reduced by lessening the initial belt tension.

Maintenance of Windings. Dirt, heat, moisture, poor lubrication, and vibration have been cited as the principal causes of mechanical failure of motors. Since poor lubrication usually produces heat and vibration, these same conditions prove also to be the chief hazards to the stator winding, and particularly to its insulation.

Dirt and air-borne dust can cause shorts and winding failures in various ways. It can impair the ventilation and lead to overheating. It can be responsible for insulation damage when it is carelessly removed. Dust that is free from oil and grease can be removed safely by wiping with a clean, dry cloth, but the preferred method is by suction. Pressure air may be used for blowing dust from inaccessible places but it should be clean, dry air of not more than 30 to 50 psi pressure.

When oil or grease makes the dust sticky, the wiping cloth should be moistened (not saturated) with a nontoxic petroleum solvent of the "safety type" (When using these solvents, wear suitable gloves to prevent skin irritation). Avoid unnecessary dismantling of motors for cleaning, especially in motors of the enclosed type. Since dirt cannot reach the interior of a properly designed enclosed motor, it is sufficient to keep the external surfaces clean and the air passages free and unobstructed.

In open motors of older design, which usually permit visual inspection of the interior, it is relatively simple to detect any heavy accumulation of dirt on the windings. Modern open motors of dripproof design may not permit similar inspection, but a heavy concentration of dust in the atmosphere and dirt deposits around the ventilation inlets may indicate that the interior needs cleaning. Even so, dismantling should be avoided unless other clues such as high frame temperature, odor of hot insulation, unusual noises, or a marked reduction in air flow are observed. The amount of dirt discharged from the motor when an airhose is inserted in the vent openings may also indicate whether the motor needs to be dismantled for cleaning.

Heat dries out insulation and causes

it to age and crack. An old rule of thumb states that the life of insulation is reduced by half for every 10 degrees C increase in temperature above normal temperature. Excessive heating may be caused by overload or by the poor ventilation that results when dirt or other obstructions hamper air flow or heat transfer. Heat may also be caused by high ambient temperature, in which case the insulation should be chosen to suit the condition (Class B or Class H insulation). Since excessive heat is most damaging and is relatively easy to detect by feel of the hand or thermometer checks, (not to mention the characteristic odor of overheated insulation) every effort should be made to remove the reasons for excessive heating.

Allowable operating temperatures, as measured by thermometer on the hottest accessible point of motor adjacent to insulation, are shown in Table 1.

"Moisture" lowers the insulation resistance of the motor, thus making the machine more vulnerable to shorts and grounds. Take care to protect dripproof motors from accidental hosing or deflected spray. Before blowing out motor windings with air, be sure that water has not condensed in the air line. A humid atmosphere will not normally cause trouble if the motor is running continuously since the heat generated in the windings will usually keep the insulation dry.

Stand-by motors should be protected from excessive moisture and the insulation resistance should be checked at regular intervals with a "megger" to reveal the condition and presence of moisture. Although the megger is not a highly accurate instrument and should not be used for absolute measurements of the insulation resistance, it is useful to obtain an indication of deterioration in the insulation. If the insulation resistance in a motor decreases appreciably, the windings must be dried before applying power to the motor. This is important where ambient temperature is subject to great and frequent fluctuations or where the atmosphere is exceptionally humid. In less severe locations, stand-by motors may be protected from moisture and condensation if they are run for a few minutes once a week.

Moisture is also detrimental to bearings and machined and unpainted surfaces. Take care that grease films provided to protect such surfaces in the motor assemblies are intact. Where moisture conditions are adverse, machined fits should occasionally be coated with a water-repellent grease. This grease should not be permitted to come in contact with windings or insulation.

"Vibration" is a common source of insulation and winding failures caused by mechanical fatigue. This hazard can effect both conductors and insulation. Since vibration is harmful to every part of the motor and is also very annoying to personnel, it should not be tolerated for any prolonged period. To avoid failures caused by vibration, a few simple checks should be made regularly: (a) check for foundation settling or heavy floor loading (these may cause vibration by misalignment); (b) check for excessive belt- or chain-tension, or shifts in the mounting due to the push-apart forces inherent in spur gearing; (c) check the motor mounting bolts, the bracket bolts, and the pulley or coupling to be sure they are fastened securely.

Repair of Failed Windings. In spite of all precautionary measures, winding failures will occur from time to time and will require repair. The first step is to determine why the winding failed and then to remove the cause so as to avoid repetition. In smaller motors with mush-wound or random-wound coils, a winding failure will generally require that the entire winding be replaced. The old winding should be carefully stripped, and all remnants of the insulation removed. For replacement, it is preferable to obtain a complete set of coils and insulation components from the motor manufacturer, since this takes guesswork out of the replacement winding and assures the use of materials of the proper quality and dimensions. If this is not possible, turns, wire size, connections, coil dimensions, and other data should be carefully noted so that the proper replacement winding can be made. It is imperative that insulation materials of satisfactory dielectric and mechanical strength be used.

Before starting the rewind job, the stator core should be carefully inspected; bent laminations should be straightened; and all rough or sharp edges should be smoothed in the areas contacting the slot cell. After the stator is wound, the coils should be snug in the slot, fillers being inserted

TABLE 1
Allowable Motor Operating Temperatures

Motor Enclosure	Class A	Class B	Class H
Open	90 C.	110 C.	150 C.
Totally enclosed, fan cooled	95 C.	115 C.	155 C.
Totally enclosed, nonventilated	95 C.	115 C.	160 C.

if necessary. It is important to eliminate voids that can trap dirt or moisture, and to secure the coils against vibration.

The final and most important operation is to give the wound stator at least two dips and bakes in an insulating varnish of good quality (Suitable varnishes and information on their proper application are available from the motor manufacturers). The purpose of this varnish treatment is to fill all the voids and crevices in the winding, and to increase the dielectric strength of the insulation system. Much greater penetration of the varnish is gained by applying it by dipping or by the vacuum process, rather than by brushing or spraying. Hence, the former methods are strongly recommended. On a new winding, the insulation is fresh, flexible, and resistant to the deteriorative effects of moisture and agents. As the insulation ages, it shrinks, becomes brittle, and is much more liable to failure. Periodic cleaning, followed by varnish treatment, will combat this tendency and help the winding retain its newness over a long span of time.

For larger motors, which use form wound coils, the same general comments apply but with certain differences: First, individual coils that have failed can, in many instances, be replaced without rewinding the entire stator. Second, because of the more precise coil shape, it is highly desirable to procure replacement coils from the motor manufacturer. Third, the varnish dip and bake is applied to individual coils prior to their insertion in the stator. Hence, varnish application to the wound stator by brushing or spraying is acceptable.

A good maintenance practice for stator windings is to be prepared for failures before they occur. When the motor is purchased, renewal parts data should be obtained from the manufacturer at that time. For motors in critical applications, it may be well to stock the renewal parts in the maintenance department; often it may be desirable to stock complete spare motors. Care should be taken that the storage area for such spare

parts or motors is clean and dry. If not, the insulation on these spares may age almost as rapidly as that of motors in service.

SPECIAL PRECAUTIONS

Unobstructed Ventilation. In order to maintain operation at rated load without exceeding the nameplate temperature rise, it is important that the normal motor ventilation be unimpaired. If any type of protecting enclosure is supplied, it must not obstruct the free flow of air around the motor. The ventilating passages of open and totally enclosed fan-cooled motors should be kept free and clean of dirt, nor should accumulations of dirt be allowed to blanket totally enclosed non-ventilated motors, since this will hinder the dissipation of heat from the motor surface. Built-in applications should have the approval of the manufacturer's design engineers to be sure that adequate ventilation is attained.

Proper Application. Some of the more obvious types of misapplication involve ambient temperature. Standard motors are designed to operate in a maximum ambient temperature of 40 C (104 F). This ambient temperature should not be exceeded unless the motor has been specially designed or otherwise made suitable for this use. Motors with Class B or Class H insulation are usually required for high ambient applications.

For proper loading, it is necessary that the motor rating and the requirements of the load be properly matched. A simple tong ammeter is excellent for ensuring that load current agrees with the value on the motor nameplate, but more versatile and accurate instruments are at times desirable. The nameplate of many 40-degree C-rise motors will indicate that they carry a "service factor," which means that the motors can safely be overloaded by a stated percentage of rated load. In the range of loading thus allowed, the increase in operating current will vary directly with the increase in load.

In the area of proper electrical design, there are a number of basic designs of induction motors, each suited to a particular field of application by reason of its specific performance characteristics. It is important that the motor design and the application requirements be mutually compatible.

Proper mechanical enclosure for the application is also important. There are two broad enclosure classifications, open and totally enclosed; each is divided into more specific subclassifications. The most common error made with enclosures is to install open motors in locations that require the use of totally enclosed motors. While open motors are priced below enclosed motors and are adequate (indeed preferable) for many industrial and most commercial purposes, they do have limitations. To cool an open motor, external air is drawn in through the ventilation openings and made to pass over and around the windings. Open motors should be used only where the air contains nothing that might be harmful to the interior of the motor. A certain amount of dust, dirt, etc. can be tolerated, providing the material is not conductive or severely abrasive or corrosive.

Although the squirrel-cage induction motor is highly rugged, proper care should be exercised for dismantling and subsequent reassembly. The use of chisels and similar sharp-pointed instruments should be avoided in removing the end brackets; after the bolts are disengaged, a few light taps with a rawhide mallet should suffice to release the brackets from the frame. Be sure that bolts holding inner bearing caps are removed before trying to withdraw the rotor. Do not attempt to pull an oversize internal fan through the stator bore; instead, remove the rotor from the opposite end. It is important to become familiar with the construction details of a particular motor by reading the manufacturer's instructions before starting to dismantle.

A most important point is to take care that the rotor is not bumped or scraped against the end turns of the stator winding when it is being removed from or inserted in the stator. If the rotor weight is such that it is awkward to manage by hand, use a crane lift to handle it in or out.

On sleeve bearing motors, drain the oil reservoirs before dismantling. On ball bearing motors, protect the bearings of a dismantled motor from dirt, dust, and moisture particularly if the bearings are of the open type. Avoid touching the bearings or other polished metal surfaces so that the moisture from your fingers will not attack the surface. Good housekeeping, cleanliness and care are just as important in the maintenance shops as on the production line, possibly more so because the vulnerable internal parts of the motor are exposed.

The combination of electricity and rotating parts in the electric motor requires strict adherence to common sense safety rules to avoid injury to personnel. Wear goggles when blowing out dirt; wear gloves when handling cleaning solvents; avoid prolonged exposure to toxic fumes; take care that flammable solvents are not ignited. Suitable precautions are necessary not only to protect those who maintain the equipment, but also to protect those who operate it. ##

About the Authors

Samzelius

Woll

John W. Samzelius is a mechanical engineer for Westinghouse Electric Corp., Buffalo, N. Y., where he handles mechanical developments and field trouble investigations. He graduated from Chalmers Institute, Gothenburg, Sweden in 1919 with a M.E. degree and has had over 30 years of professional experience including six years in street railway engineering in Sweden, 26 years in electric motor design, and seven years in control apparatus design for Westinghouse.

Richard F. Woll is a designer in the AC Motor Engineering department of Westinghouse Electric Corp.'s Buffalo, N. Y. plant. He received his B.S. degree in electrical engineering from the University of Pittsburgh and has had 20 years of experience with Westinghouse—two years on the test floor and 18 years in designing different types of AC motors.

New Approach to NPSH

For design purposes, this new correlation will mean adequate suction head for pump operation.

Lloyd T. Hendrix
Richfield Oil Corporation, Bakersfield, Calif.

HERE IS HOW "cold water NPSH" can be used to assure adequate suction head for good pump operation when pumping hydrocarbons. The proposed design results from a study of actual test data on pumps handling hydrocarbons. The data were obtained by a committee of the California Natural Gasoline Association and were presented to the 1957 Fall Meeting.[1] A correlation between the hydrocarbon test data and cold water tests had not been found at that time. Further study of writings by Stepanoff[2] and Whistler[3] provided the spark which suggested trying this procedure.

NPSH is short for net positive suction head and is equal to the total suction head minus the vapor pressure (at flow conditions) of the liquid being pumped. Both values are expressed in feet of liquid, absolute. The total suction head is the suction pressure measured at the suction nozzle, corrected to the pump centerline as a datum, plus the velocity head at the point of measurement. The velocity head is based on the average velocity at the suction nozzle and equals $U^2_{avg.}/2g$.

The cold water NPSH can be determined (1) by pinching the suction valve to the pump or (2) by lowering the pressure in the vapor space of the water surge tank by a vacuum pump. It's assumed that the valve pinching procedure is the test method used and that the recirculated water was exposed to air on its return route to the water surge tank. In any given test, the static pressure at the pump suction flange, the flow rate, the suction temperature, the discharge pressure and the barometric pressure are measured. The vapor pressure used is that of pure water.

The NPSH has been interpreted in many publications as representing the energy necessary to get the liquid from the pump suction to the lowest pressure point in the impeller entrance at incipient vapor formation. This in turn has led to discussions on the kinetics of bubble formation. This has also involved discussions of the rates of heat and mass transfer. Finally, there has been the problem of pressure loss due to friction or turbulence. But for installation design purposes, at least, a new interpretation and use of NPSH needs to be adopted.

The "cold water" NPSH as determined is a relatively good measure of the maximum volume of vapor per volume of liquid (V_v/V_L) which a pump will handle satisfactorily at a given liquid flow rate. It's assumed that the pump will handle the same V_v/V_L for any other fluid. It would It would be better if this V_v/V_L could be measured directly at the impeller eye. Such a practice may develop, but a better design basis is needed now. Sometime, the pump industry may provide V_v/V_L data for their pumps along with the pressure drop from the suction flange to the lowest pressure point in the impeller eye.

Determination. The "cold water" NSPH is used to determine the V_v/V_L as follows:

1. Assume the water used to test the pump was air saturated.
2. Assume the solubility of air in water follows Henry's law. Henry's law says the mole fraction of a dissolved gas in a dilute solution is proportional to the partial pressure of the gas above the solution.
3. Assume that vapor-liquid equilibrium has been established in the pump suction during the test. This means bubbles have formed from air coming out of solution at the lower pressure.
4. Compute the absolute pressure at the suction flange for the maximum expected flow rate. This pressure is referred to from here on as "test suction pressure." Problem 1 shows how to compute it.
5. Use the air-water V_v/V_L versus absolute pressure curves in Figure 1 to obtain the V_v/V_L corresponding to the "test suction pressure." Temperature of the test water should be known for both 4 and 5. The development of V_v/V_L curves for dilute solutions is shown in Problem 2.

Primary interest is in applying V_v/V_L to hydrocarbon systems so that the minimum safe pressure at the pump suction flange can be computed. Knowing this pressure, the rest of the pump supply system can be designed. That is, piping can be sized and laid out and the minimum elevation of the supply vessel determined. To apply V_v/V_L to hydrocarbons requires that a V_v/V_L versus absolute pressure curve is developed for the material. There are two systems to which this method applies and they require slightly different computational procedures. One system is open to atmosphere and the other closed.

Open Systems. The open system is at atmospheric pressure and the hydrocarbons will have air dissolved in them. The vapor pressure of the air-hydrocarbon solution will be atmospheric pressure. This will be a dilute solution and should follow Henry's law ($p_1 = X_1 H_1$). This equation can be used to solve for X_1 at atmospheric pressure. Then, using the resulting composition and assuming, say 13 psia, 10 psia and 5 psia pressure on the liquid at the pump suction, compute the new X_1's (see Problem 1). Since X_2—the mole fraction of oil or water—is about 0.999, its change with air coming out of solution cannot be great. So the difference in X_1's is used to determine the actual amount of air released. There will also be oil or water vapor released with the air. The amount depends on the vapor pressure of air-free oil or water. Figure 2 shows some data on the solubility of air in oil and

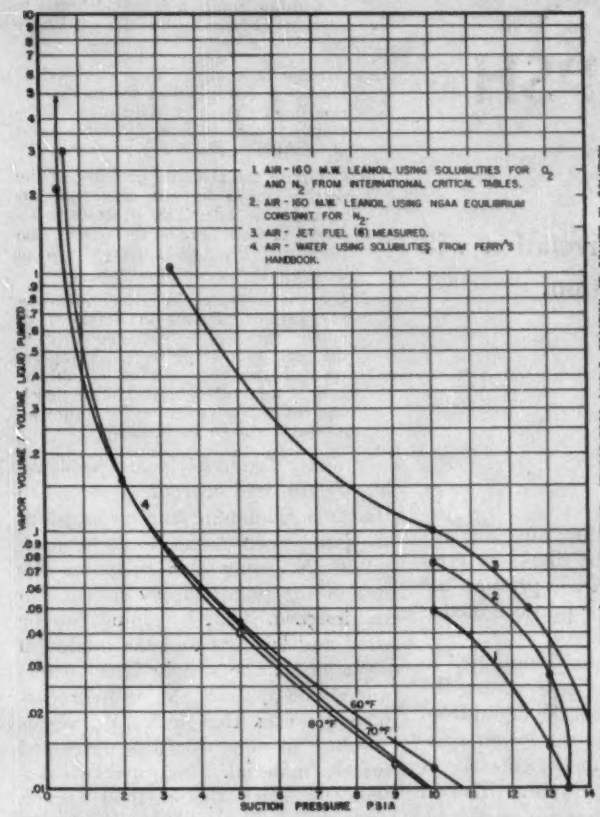

1. AIR - 160 M.W. LEANOIL USING SOLUBILITIES FOR O_2 AND N_2 FROM INTERNATIONAL CRITICAL TABLES.
2. AIR - 160 M.W. LEANOIL USING NGAA EQUILIBRIUM CONSTANT FOR N_2.
3. AIR - JET FUEL (6) MEASURED.
4. AIR - WATER USING SOLUBILITIES FROM PERRY'S HANDBOOK.
60°F
80°F
70°F
VAPOR VOLUME / VOLUME LIQUID PUMPED
SUCTION PRESSURE PSIA

FIGURE 1—Vaporization curves for air-water, air-lean oil and air-jet fuel: From "cold water" NPSH, the ratio of vapor-liquid volumes can be found.

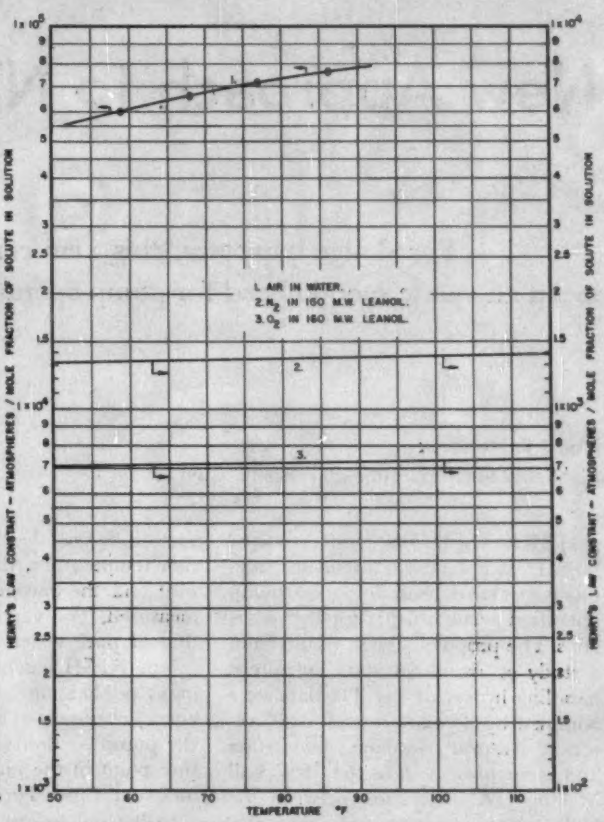

1. AIR IN WATER.
2. N_2 IN 160 M.W. LEANOIL.
3. O_2 IN 160 M.W. LEANOIL.
HENRY'S LAW CONSTANT - ATMOSPHERES / MOLE FRACTION OF SOLUTE IN SOLUTION
TEMPERATURE °F

FIGURE 2—Henry's law constants can be applied up to total pressures of 1 atmosphere.

water. Problem 3 shows the computational method.

Closed Systems. Vapor pressure in closed hydrocarbon systems does not usually follow Henry's law, but rather shows a non-ideal behavior. Therefore, the vapor pressure is best evaluated by using empirical data such as NGAA equilibrium constants and phase compositions determined by fractional analysis. It's assumed that the material is in equilibrium with the pressure of the vapor space of the pump supply vessel.

The pressure in the vapor space is used as the vapor pressure. This will usually necessitate computing the composition of the liquid from the vapor composition using equilibrium constants. It will also require knowledge of how the vapor composition can change. The range of operating conditions must be examined. Consider how fast temperature and pressure can vary in the supply vessel and the effect on vapor formation. New plant design is going to require some imagination by the engineers to be sure the pump supply conditions are properly visualized. See Problem 4.

Vapor pressures can be measured if samples of the materials are available, but it is recommended that an apparatus[3] having the principles shown in Figure 3 be used, not the Reid or LPG type equipment. The vapor volume formed at operating temperature and different pressures should be measured relative to the volume of residual liquid. This information could then be used to plot a curve of V_v/V_L versus absolute pressure. The range for such tests need not be extended beyond 10 volumes of vapor per 100 volumes of liquid and should be most accurate in the range of 1 to 3 volumes of vapor per 100 volumes of liquid. This is the probable range that fits the pump.

The vapor pressure has been established and other properties such as composition and density have been fixed; or at least their range of variation has been fixed. If the suction temperature varies over a range, compute vapor volume data at the high

About the Author

Lloyd Hendrix is a chief process engineer for Richfield Oil Corp., Bakersfield, Calif., where he develops, evaluates, and designs new plants and major plant revisions for the company's Natural Gasoline division. He has B.S. and M.S. degrees in chemical engineering from Ohio State University. Hendrix was formerly with C. F. Braun & Co., Corning Glass Works, Pan American Refining Co. and did research work at Battelle Memorial Institute.

and low temperatures. Plot the lines of vapor volume per liquid volume versus suction pressure for constant suction temperature as in Figure 1. Pick from the cold water curves the V_v/V_L at the "test suction pressure", computed from the cold water NPSH data, at the maximum flow rate anticipated for the pump. Now find the suction pressure for which the hydrocarbon liquid has the same V_v/V_L. This is the minimum suction pressure.

Using this minimum suction pressure, add enough head to take care of variations expected in operations. For example, it may be determined that a back pressure regulator on the vapors in the vessel can hold its set value within 2 percent. So, 2 percent of the vessel operating pressure should be added to the minimum suction pressure. Then start at this suction pressure and work backwards through the piping to the supply vessel to determine the required elevation of the minimum expected liquid level above the suction nozzle. It may be necessary to provide means of increasing the head without increasing the vessel elevation. This is left to the ingenuity of the engineer designing the installation. Vapor compression and recycle is one very good method.

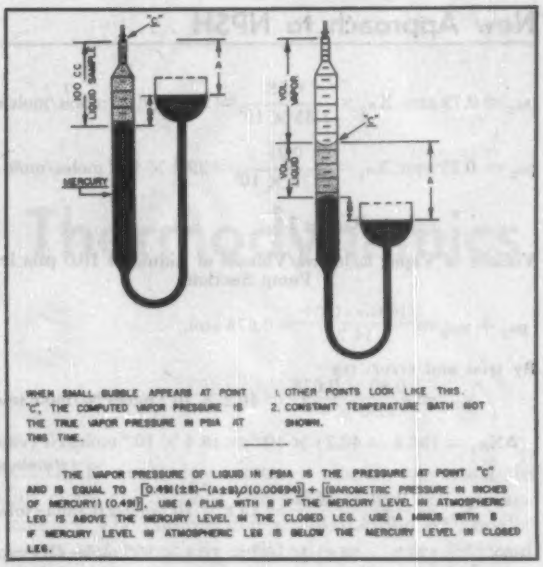

"C"
200 CC. LIQUID SAMPLE
A
B
MERCURY
VOL. VAPOR
VOL. LIQUID
"C"
A
B
WHEN SMALL BUBBLE APPEARS AT POINT "C", THE COMPUTED VAPOR PRESSURE IS THE TRUE VAPOR PRESSURE IN PSIA AT THIS TIME.
1. OTHER POINTS LOOK LIKE THIS.
2. CONSTANT TEMPERATURE BATH NOT SHOWN.
THE VAPOR PRESSURE OF LIQUID IN PSIA IS THE PRESSURE AT POINT "C" AND IS EQUAL TO [0.491(±B)−(A±B)(0.00894)] + [(BAROMETRIC PRESSURE IN INCHES OF MERCURY) (0.491)]. USE A PLUS WITH B IF THE MERCURY LEVEL IN ATMOSPHERIC LEG IS ABOVE THE MERCURY LEVEL IN THE CLOSED LEG. USE A MINUS WITH B IF MERCURY LEVEL IN ATMOSPHERIC LEG IS BELOW THE MERCURY LEVEL IN CLOSED LEG.

FIGURE 3 — Apparatus for measuring V_v/V_L at different system pressures[3].

This V_v/V_L approach was applied to the data obtained by the CNGA committee and was found to agree for lean oil, a mixture of butanes and natural gasoline, and a mixture of propane, butanes and gasoline. This CNGA data was for two pumps. There was a large number of runs made and the agreement was satisfactory for this range of materials. More pumps and more liquids should be tested; but in the meantime, this design procedure will serve well.

PROBLEM 1—TEST SUCTION PRESSURE

We have a 2-inch diameter pump suction. The "cold water" NPSH at maximum cold water capacity of 180 gallons per minute (gpm) is 18 feet of water at 80 F.

"Test suction pressure," psia = NPSH, psia + water vapor pressure, psia — velocity head, psia.

0.433 is the conversion factor from feet of water to psia.

$U_{ave.} = 18$ feet per second.

Velocity head in psia $= (1.08 \times 10^{-4})\ U^2_{ave.} \times \rho$.

1.08×10^{-4} is factor to correct for the units used.

ρ is density pounds per cubic foot.

$p_w = 0.507$ psia[5].

So, we have

"Test suction pressure," psia $= 18 \times 0.433 + 0.507 - (1.08 \times 10^{-4})\ (18)^2\ (62.3) = 7.8 + 0.507 - 2.18 = 6.13$ psia.

From curve 4 — 80 F.—Figure No. 1, we find that V_v/V_L is *0.028*.

PROBLEM 2—V_v/V_L CURVES FOR WATER

To obtain values of V_v/V_L to plot versus the absolute pressure for water, we assume water enters the piping to the pump saturated with air and that it follows Henry's law, $p_1 = X_1 H_1$. We assume different absolute pressures and compute the corresponding V_v/V_L as follows:

For one point on curve 4, Figure 1, at 80 F.,

$$p_w = 0.507 \text{ psia}^5.$$

In the tank at 14.7 psia

$$X_A = \frac{(14.7 - 0.507)}{14.7 \times 7.4 \times 10^4} = 1.305 \times 10^{-5} \text{ moles air/mole solution.}$$

In the pipe at 5 psia

$$X_A = \frac{5 - 0.507}{14.7 \times 7.4 \times 10^4} = 0.413 \times 10^{-5} \text{ moles air/mole solution}$$

$$y_A = \frac{5 - 0.507}{5} = 0.8986$$

$\Delta X_A = (1.305 - 0.413)\ 10^{-5}$ moles air vaporized $= 0.892 \times 10^{-5}$.

Actual volume of air released

$$= \frac{\Delta X_A}{y_A} \times 380 \times \frac{14.7}{P_p} \times \frac{T_p}{520}$$

Where 380 = cubic feet of vapor in 1 lb. mole at 60 F., 14.7 psia

P_p = pressure in pipe, psia

T_p = absolute temperature of fluid in pipe = (°F + 460) °R.

Actual volume

$$= \frac{0.892}{0.8986} \times 380 \times \frac{14.7}{5} \times \frac{540}{520} = 0.0115 \text{ cu. ft.}$$

Actual volume of liquid

$$\simeq \frac{\text{molecular weight of water}}{\text{density of water}} = \frac{18}{62.3} = 0.288 \text{ cu. ft./lb. mole}$$

$V_v/V_L = 0.0115/0.288 = 0.04$ cu. ft. vapor/cu. ft. solution.

PROBLEM 3—PUMPING 160 M.W. LEANOIL

If we were pumping 160 M.W. leanoil from atmospheric storage with the pump in Illustrative Problem 2, we know our V_v/V_L is 0.028. We could compute a V_v/V_L curve for leanoil as shown below. We would look at a V_v/V_L of 0.028 on this curve (curve 1—Figure 1) and find 11.8 psia as the required pressure at the suction flange. Actual tests on this situation showed about 11.5 to 11.8 psia required from 0 to 140 gpm.

Composition of Oil in Tank

Vapor pressure of oil, air free, is 0.04 psia computed from hydrocarbon composition.

From Figure 2

$$H_{N_2} = 1.35 \times 10^9 \text{ and } H_{O_2} = 0.72 \times 10^8.$$

Composition of air is 79 volume % N_2—21 volume % O_2.

$$X_{N_2} = \frac{P_{N_2}}{H_{N_2}}$$

$p_{N_2} = 0.79$ atm. $X_{N_2} = \dfrac{0.79}{1.35 \times 10^3} = 58.6 \times 10^{-5}$ moles/mole soln.

$p_{O_2} = 0.21$ atm. $X_{O_2} = \dfrac{0.21}{0.72 \times 10^3} = 29.2 \times 10^{-5}$ moles/mole soln

$X_{soln} \cong 1$

Volume of Vapor Released/Volume of Liquid at 10.0 psia in the Pump Suction

$$p_{O_2} + p_{N_2} = \frac{10.0 - 0.04}{14.7} = 0.678 \text{ atm.}$$

By trial and error: try

$$X_{N_2} = \frac{0.80 \times 0.678}{1.35 \times 10^3} = 40.2 \times 10^{-5} \text{ moles } N_2\text{/mole soln.}$$

$$\Delta X_{N_2} = (58.6 - 40.2) \times 10^{-5} = 18.4 \times 10^{-5} \text{ moles } N_2 \text{ (vapor) /mole soln.}$$

$$X_{O_2} = \frac{0.20 \times 0.678}{0.72 \times 10^3} = 18.8 \times 10^{-5} \text{ moles } O_2\text{/mole soln.}$$

$$\Delta X_{O_2} = (29.2 - 18.8) \times 10^{-5} = 10.4 \times 10^{-5} \text{ moles } O_2 \text{ (vapor) /mole soln.}$$

18.4/10.4 does not = 0.80/0.20

try $X_{N_2} = \dfrac{0.76}{0.80} \times 40.2 \times 10^{-5} = 38.2 \times 10^{-5}$

$\Delta X_{N_2} = 20.4 \times 10^{-5}$ moles N_2 (vapor) /mole soln.

$X_{O_2} = \dfrac{0.24}{0.20} \times 18.8 \times 10^{-5} = 22.56 \times 10^{-5}$

$\Delta X_{O_2} = 6.64 \times 10^{-5}$ moles O_2 (vapor) /mole soln.

20.4/6.64 = 3.07 0.76/0.24 = 3.16 close enough

$$\text{total vapor} = \frac{(10.0)}{(10.0 - 0.04)} (27.04 \times 10^{-5}) = 27.14 \times 10^{-5} \frac{\text{moles}}{\text{mole soln.}}$$

$$V_v/V_L = 27.14 \times 10^{-5} \times 380 \times \frac{530}{520} \Big/ \frac{160}{0.82 \times 62.3}$$

$$= 0.155 \text{ cu.ft./3.13 cu.ft.} = 0.0495$$

PROBLEM 4—PUMPING AN ACTUAL BUTANE plus MIXTURE

We are using the same pump as in Problem 1, so $V_v/V_L = 0.028$. Storage vessel vapor space pressure is 30 psia from a pressure gauge and the liquid temperature is 60 F. The liquid composition by fractional analysis is such that the computed vapor pressure using K's from NGAA is 20.6 psia. Therefore, the first thing to do is compute a new composition. We know the vapor space contained natural gas for repressuring at high pumping rates. We know that methane and ethane are supplying 9.4 psia partial pressure or that they constitute 31.36 mole percent of the vapors ($y_1 = K_1X_1$). So, if we assume a ratio between methane and ethane we can quickly solve for the mole fraction of each in the liquid.

Composition of Liquid by Fractional Analysis

Component	Mol. Fr.	From NGSMA—1957 at convergence of 3,000 psi K 60 F. 30 psia		
C_2	0.0107		3.4	$KX = 0.03638$
iC_4	0.1713		1.2	0.20556
NC_4	0.4490		0.85	0.38165
iC_5	0.1100		0.32	0.03520
NC_5	0.101		0.24	0.02424
C_6^+	0.1580	say C_7	0.021	0.00332
	1.0000			0.68635

Use ratio of methane to ethane of 9 to 1 in the vapors

$3000K_{60}^{30}$ $C1 = 84$ $C_2 = 13$

$84X_1 + 13X_2 = 0.3136 = y_{1+2}$

$$X_1 = \frac{(0.9)y_{1+2}}{84} \qquad X_2 = \frac{(0.1)y_{1+2}}{13}$$

$$X_1 = \frac{0.9\,(0.3136)}{84} = 0.00336$$

$$X_2 = \frac{0.1\,(0.3136)}{13} = 0.00241$$

Multiply old X's by 0.994 to get new mole fraction.

New Composition of Liquid

Component	Mol. Fr.
C_1	0.0034
C_2	0.0024
C_3	0.0107
iC_4	0.1703
NC_4	0.4463
iC_5	0.1093
NC_5	0.1004
C_6^+	0.1572
	1.0000

Since the sum of the mole fractions of methane and ethane in the liquid are only 0.0058, it is easy to see why a fractional analysis might not detect them.

$V_v/V_L = 0.028$. Translate into moles vapor per mole liquid.

Basis: 1 cu. ft. liquid

$$V_v = 0.028 \times \frac{520}{T_A} \times \frac{P_A}{14.7 \times 380} = 0.028 \times \frac{520}{520} \times \frac{30.0}{14.7 \times 380} = 0.00015 \text{ mole}$$

$V_L = 1$ cu. ft. liquid $\times \rho_A/\text{M.W.} = 0.625 \times 62.3/72 = 0.54$ mole

So for flash calculation, use $L/V = 0.54/0.00015$

$L/V = 3600$ moles liquid/mole vapor

Since V is so small, we compute V by $V_1 = M_1/1 + \dfrac{L}{VK_1}$. This is a rearrangement of the last equation in Nelson[4] on page 390. We use M instead of F used by Nelson[4] for the total moles of liquid and vapor.

$$V_1 = \frac{K_1 M_1}{(L/V) + K_1} = \frac{M_1}{(L/VK_1) + K_1/K_1} = \frac{M_1}{(L/VK_1) + 1}$$

1 refers to a particular component and M or V represent the summation of M_1's or V_1's. We are solving for pressure at constant temperature. The answer is 29.5 psia computed, compared to 28 to 29 psia measured for the range 0 to 140 gpm.

NOMENCLATURE

$U_{avg.}$	Average velocity feet per second.
g	Gravitational constant—32.17 feet per second at sea level.
p_1	Partial pressure of component 1 in atmospheres.
X_1	Mole fraction of component 1.
H_1	Atmospheres per mole fraction of solute 1 in solution.
y_1	Mole fraction of component 1 in the vapor.
ρ	Density—lbs. per cu. ft.
V_v/V_L	Actual volume of vapors per actual volume of liquid at pump suction.
ΔX_{N_2}	Difference between X_{N_2} at two different pressures.
P_A	Actual pressure psia.
T_A	Actual temperature (F°—460) absolute.
ρ_A	Actual density—lbs. per cu. ft.

ACKNOWLEDGMENT

A. M. Whistler for information on vapor pressure apparatus and discussion of subject matter.

LITERATURE CITED

[1] CNGA 1957 Fall Meeting Proceedings.
[2] Stepanoff, A. S., "Centrifugal and Axial Flow Pumps" 1957 ed., John Wiley and Sons, Inc.
[3] Whistler A. M.—Personal communications—1957-58.
[4] Nelson W. L., Petroleum Refinery Engineering—3rd ed., page 390.
[5] J. H. Keenan and F. G. Keyes, "Thermodynamic Properties of Steam" —John Wiley & Sons, Inc.
[6] Aerojet-General Corp., private communications.

Applied Hydrocarbon Thermodynamics

Part 6

Improved Mollier Charts for Hydrocarbons

Here are full page charts for methane, ethylene, ethane, propylene, propane, *i*-butane, *n*-butane and *n*-pentane.

Wayne C. Edmister
California Research Corporation,
Richmond, Calif.

MOLLIER (enthalpy-entropy) charts are used in making cycle calculations for refrigeration and expansion engines. The compression and expansion portions of the cycles are essentially adiabatic and reversible and thus follow constant entropy paths, which are found on Mollier charts. The entropy part of the Mollier chart is not necessary in other types of hydrocarbon processing calculations, such as heat balances.

Impurities having lower or higher boiling points than the principal component alter the properties in such a way that a pure component enthalpy-entropy chart does not apply correctly so there is not much need for a Mollier chart for hydrocarbons not used in refrigeration cycles.

Using the latest information available, enthalpy-pressure charts have been prepared for eight light hydrocarbons and are presented here. Lines of constant temperature entropy and specific volume are plotted on the "P" vs "H" coordinates. The thermodynamic data represented on these charts are consistent, both internally for each hydrocarbon and from one hydrocarbon to another.

Chart Preparation Procedure. Mollier charts are developed from three types of data: (1) heat capacities to get the effects of temperature on entropy and enthalpy, (2) volumetric (P-V-T) data for the effects of pressure on the entropy and enthalpy, and (3) vapor pressure and densities of saturated vapor and liquid. The quality of a Mollier chart is dependent upon the accuracy of these basic data and the precision of techniques used in preparing the charts.

Effects of temperature on entropy and enthalpy of the vapor phase may be computed from calorimetrically measured heat capacities or from spectroscopic data. The latter method was used by Rossini et al.[10] in preparing the tabulations of ideal gas state properties issued by API Research Project 44. The zero enthalpy datum may be at any arbitrary point, such as saturated liquid at the normal boiling point or as ideal gas at 0° R, the latter being the one used in the API 44 tabulations and in these new Mollier charts.

Starting with the ideal gas entropy (S°) and enthalpy (H°) versus temperature lines as the bases, entropy and enthalpy points for other pressures are located by measuring off the isothermal effects of pressure at each temperature. These isothermal pressure corrections to the

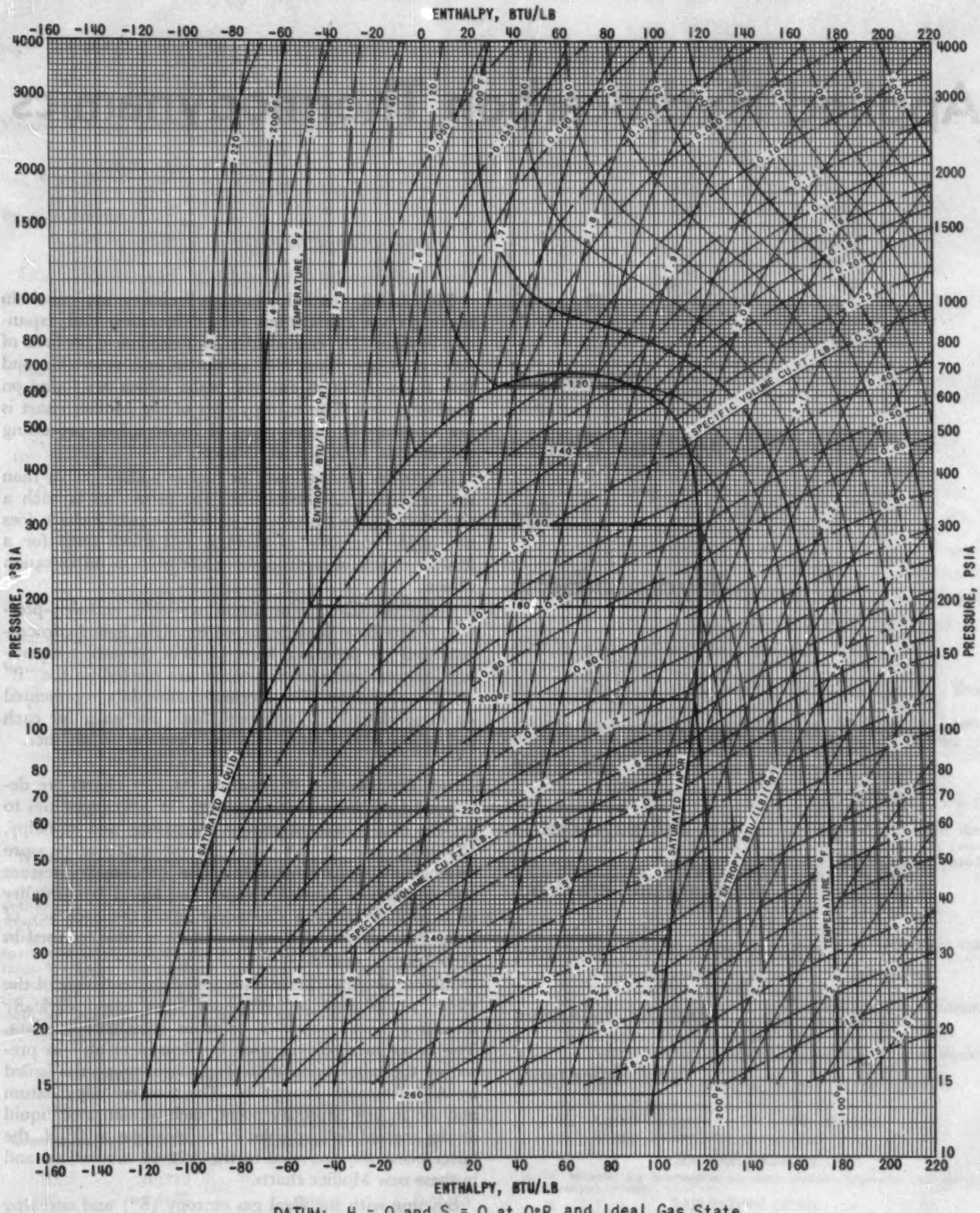
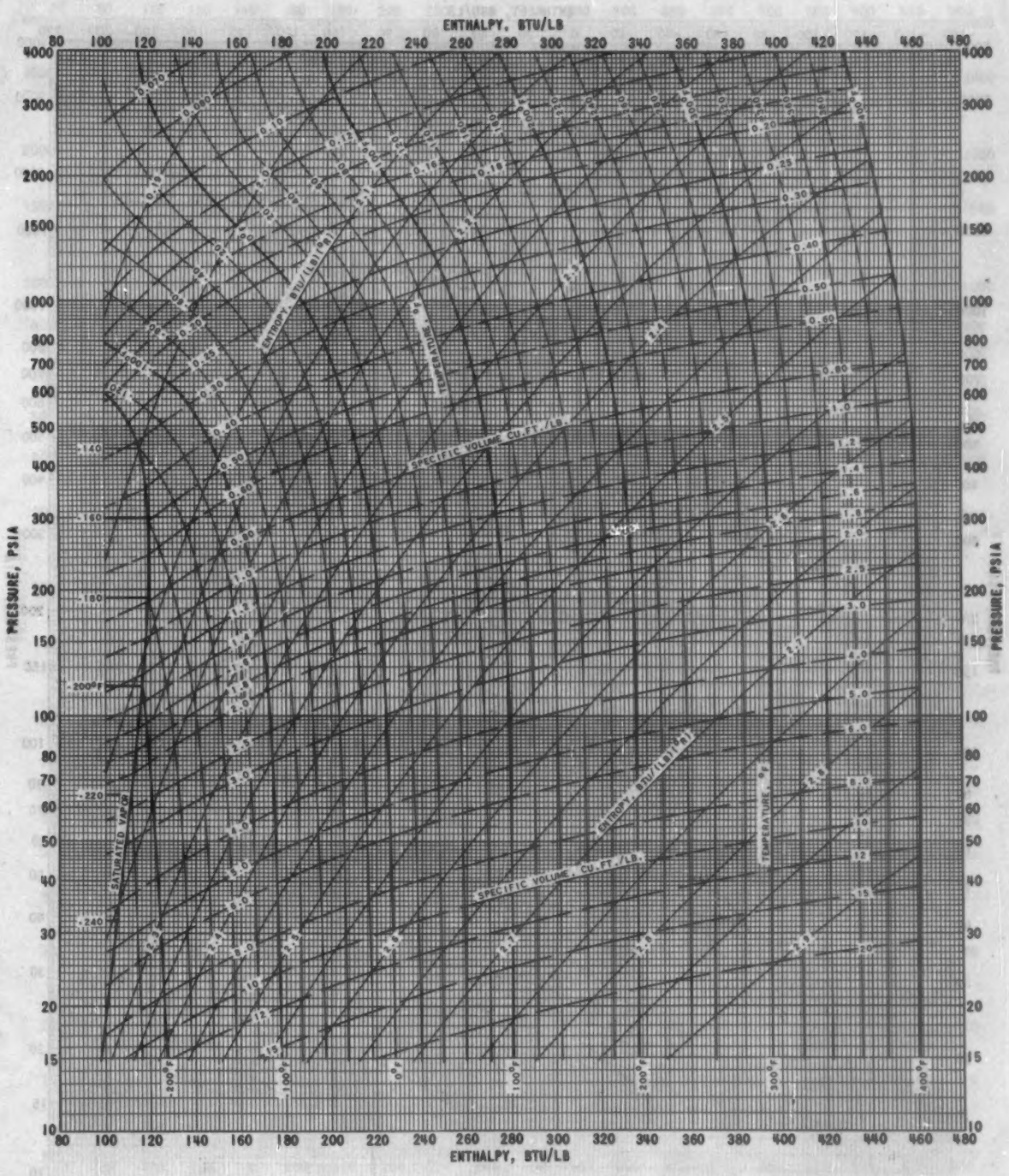


FIGURE 6.1—Mollier chart for methane (1 of 2).



DATUM: H = 0 and S = 0 at 0°R and Ideal Gas State

FIGURE 6.2--Mollier chart for methane (2 of 2).

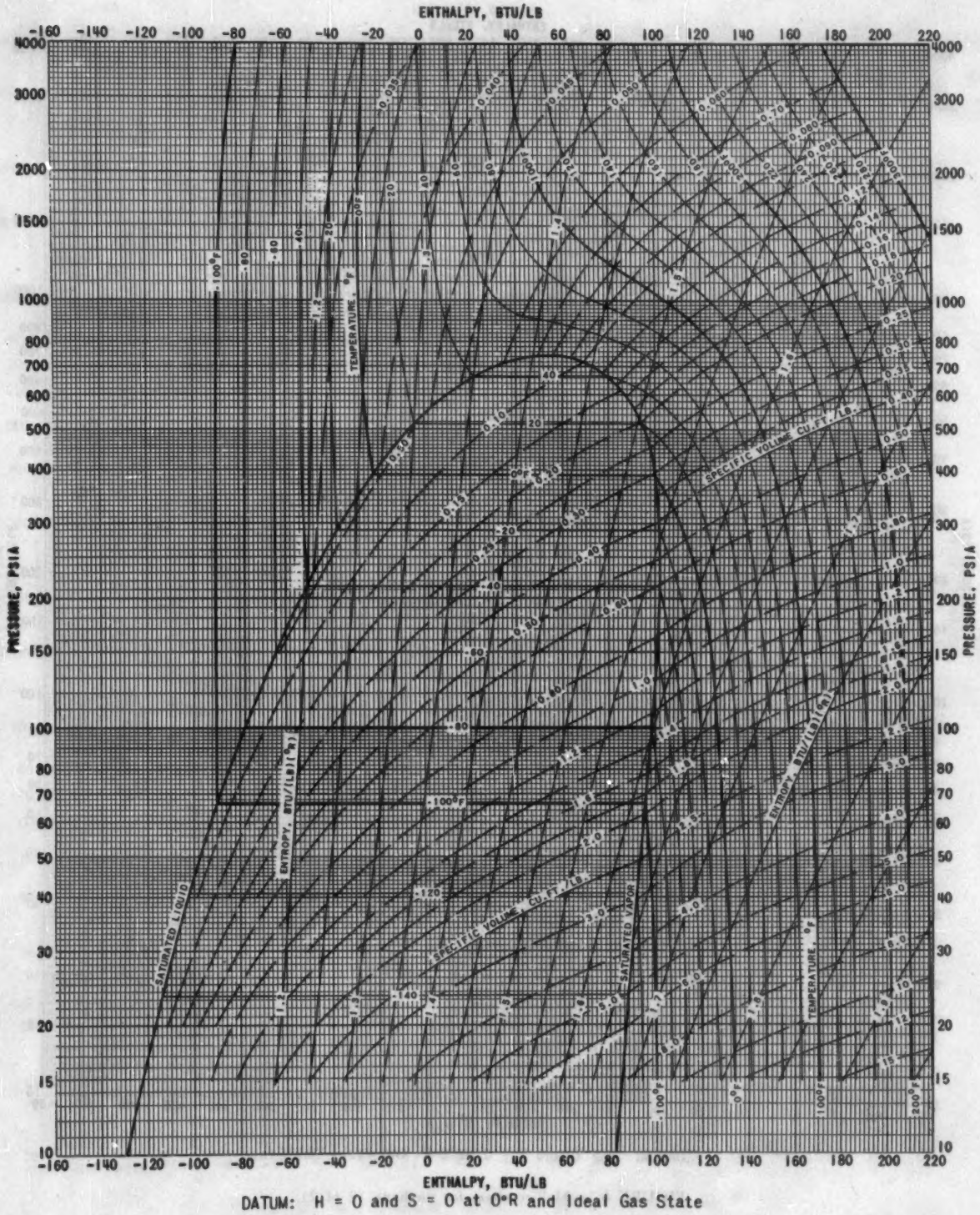


FIGURE 6.3—Mollier chart for ethylene (1 of 2).

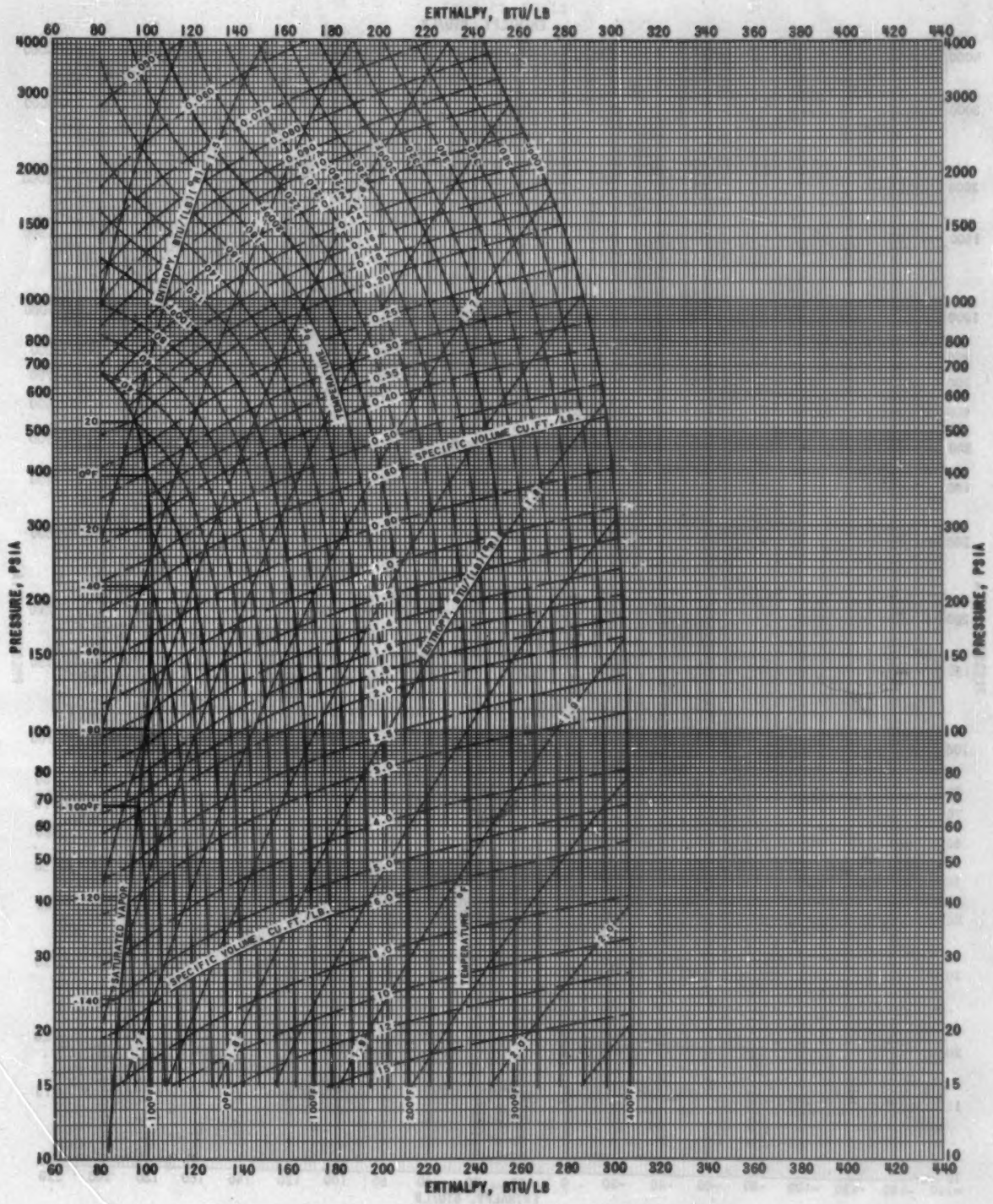


FIGURE 6.4—Mollier chart for ethylene (2 of 2).

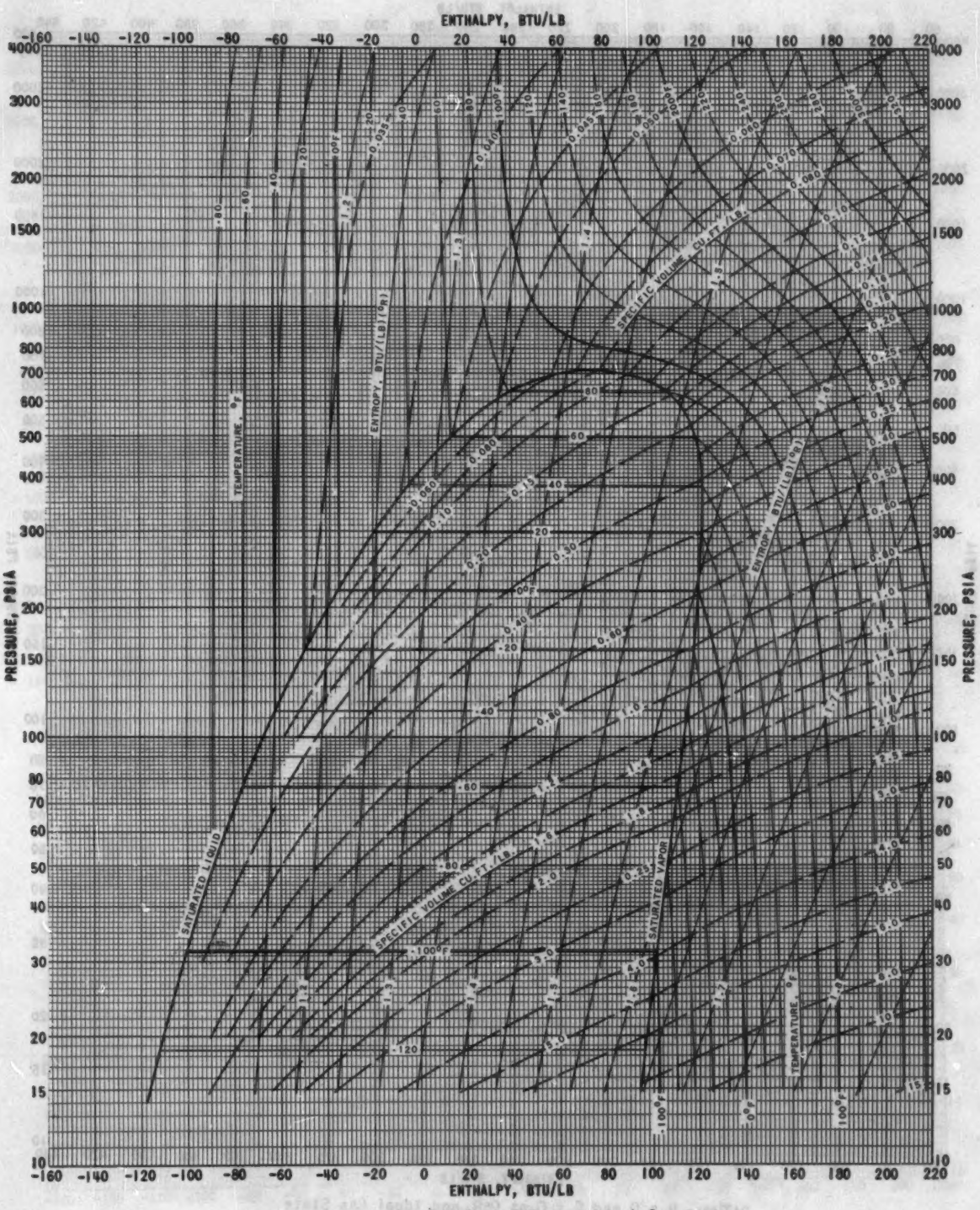
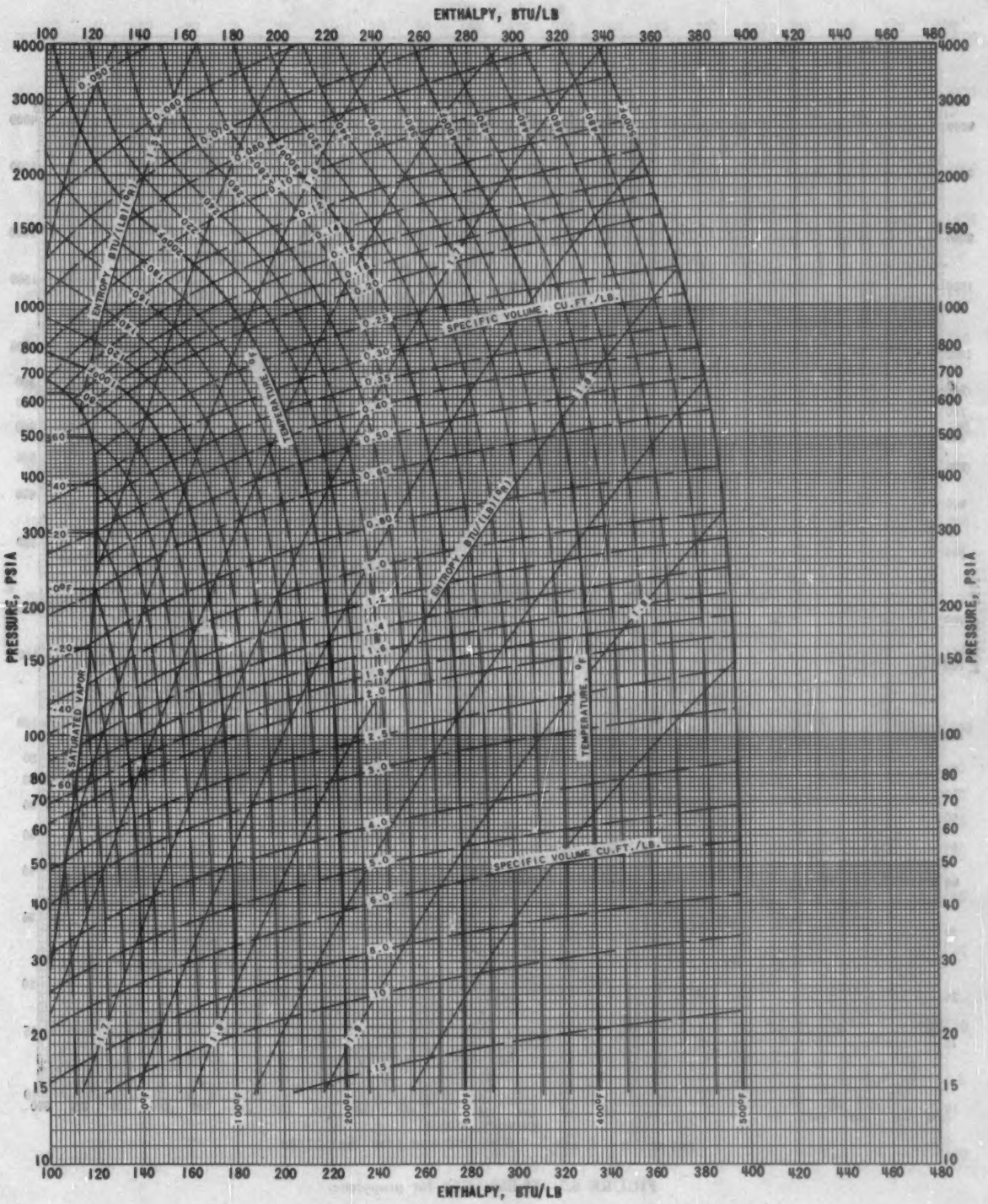


FIGURE 6.5—Mollier chart for ethane (1 of 2).



DATUM: H = 0 and S = 0 at 0°R and Ideal Gas State

FIGURE 6.6—Mollier chart for ethane (2 of 2).

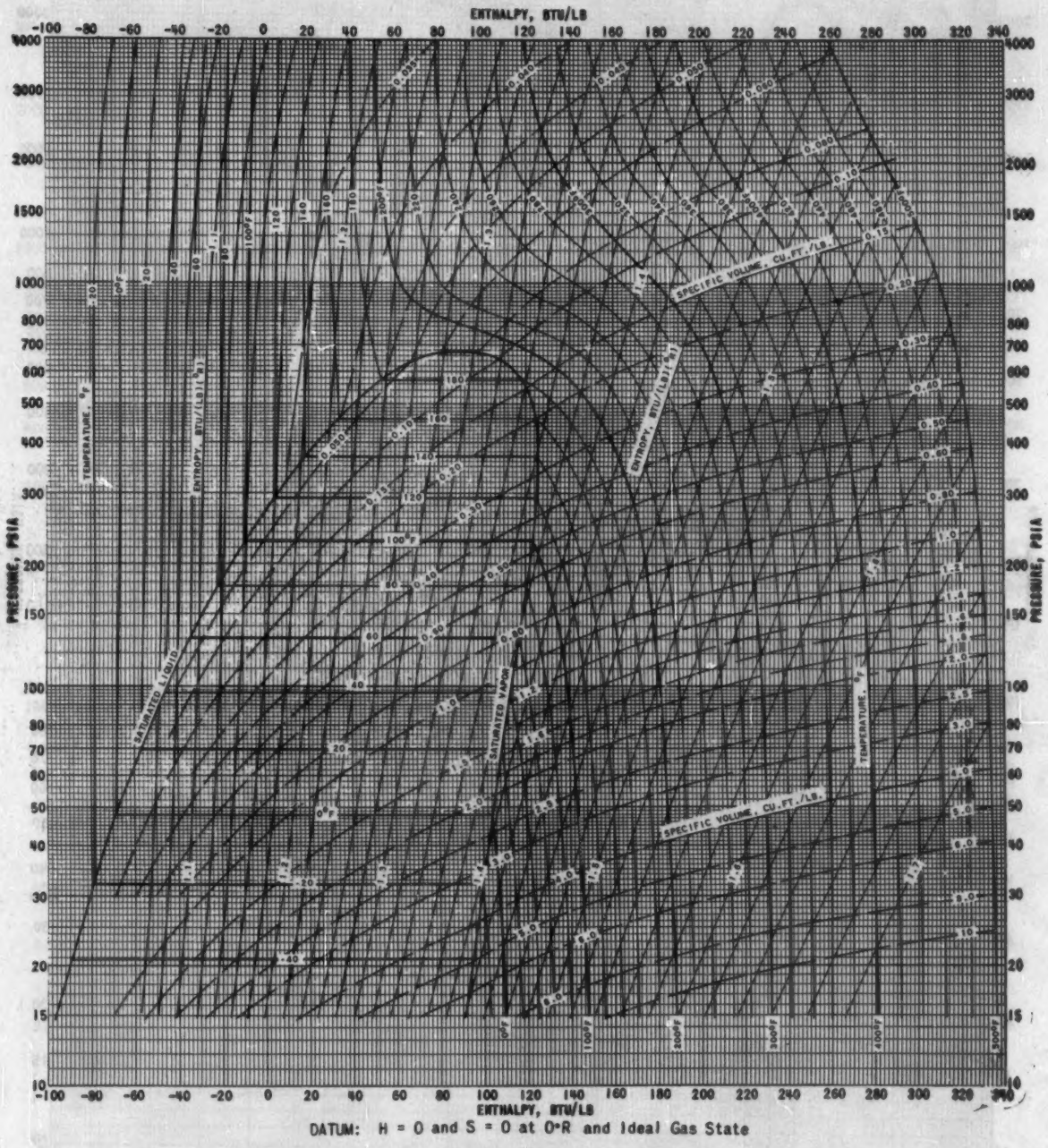


FIGURE 6.7—Mollier chart for propylene.

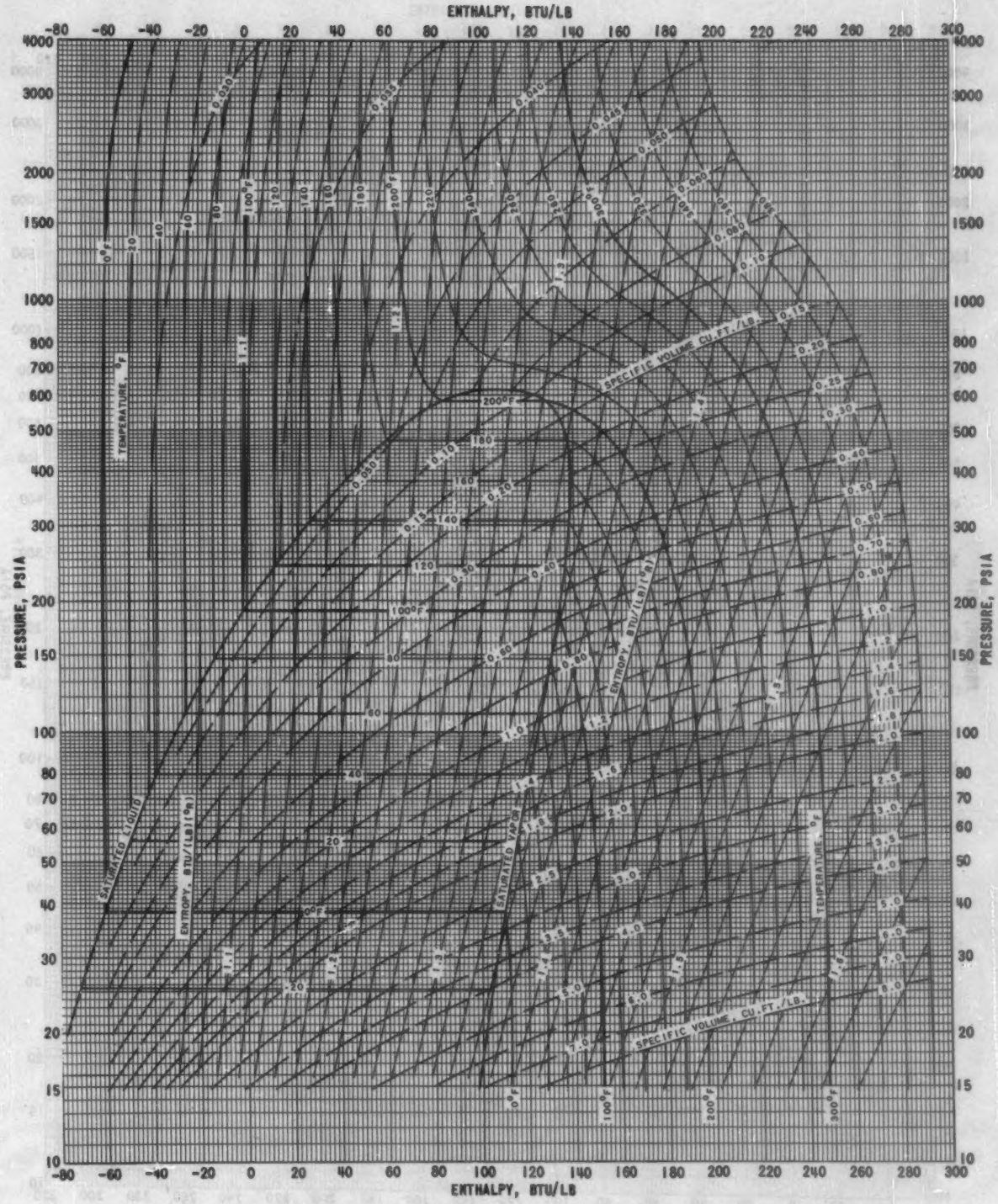
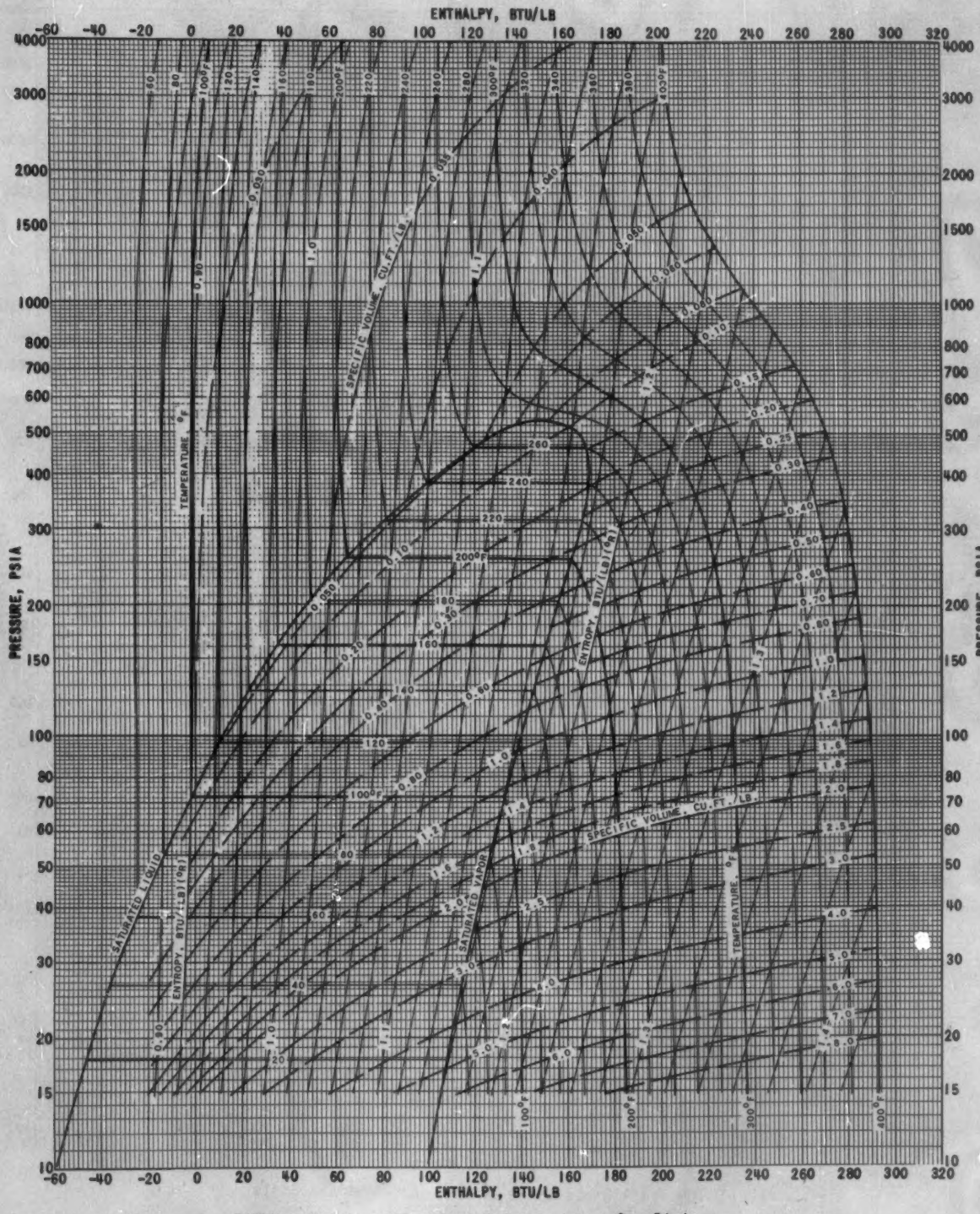
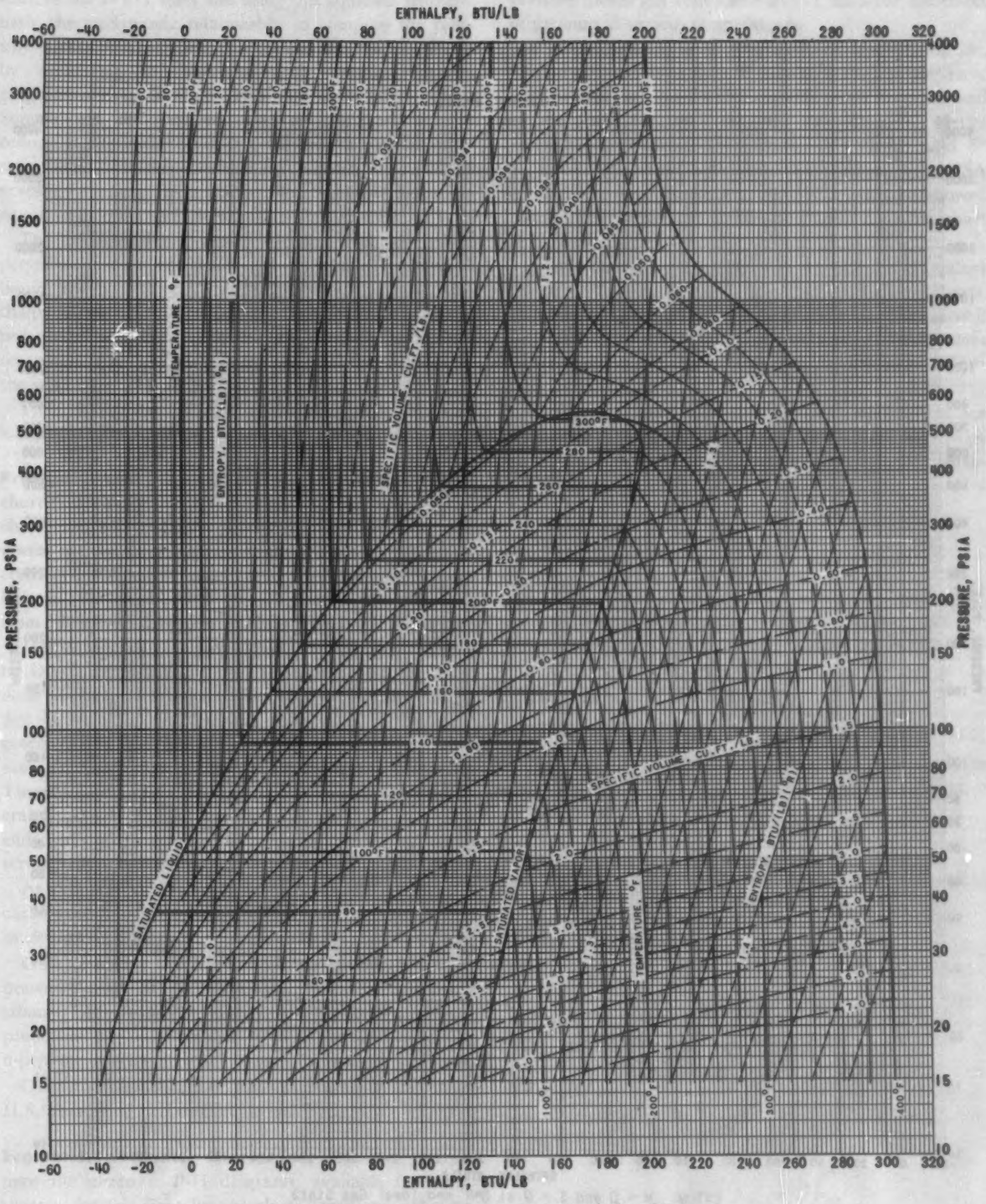


FIGURE 6.8—Mollier chart for propane.



DATUM: H = 0 and S = 0 at 0°R and Ideal Gas State

FIGURE 6.9—Mollier chart for i-butane.



DATUM: H = 0 and S = 0 at 0°R and Ideal Gas State

FIGURE 6.10—Mollier chart for n-butane.

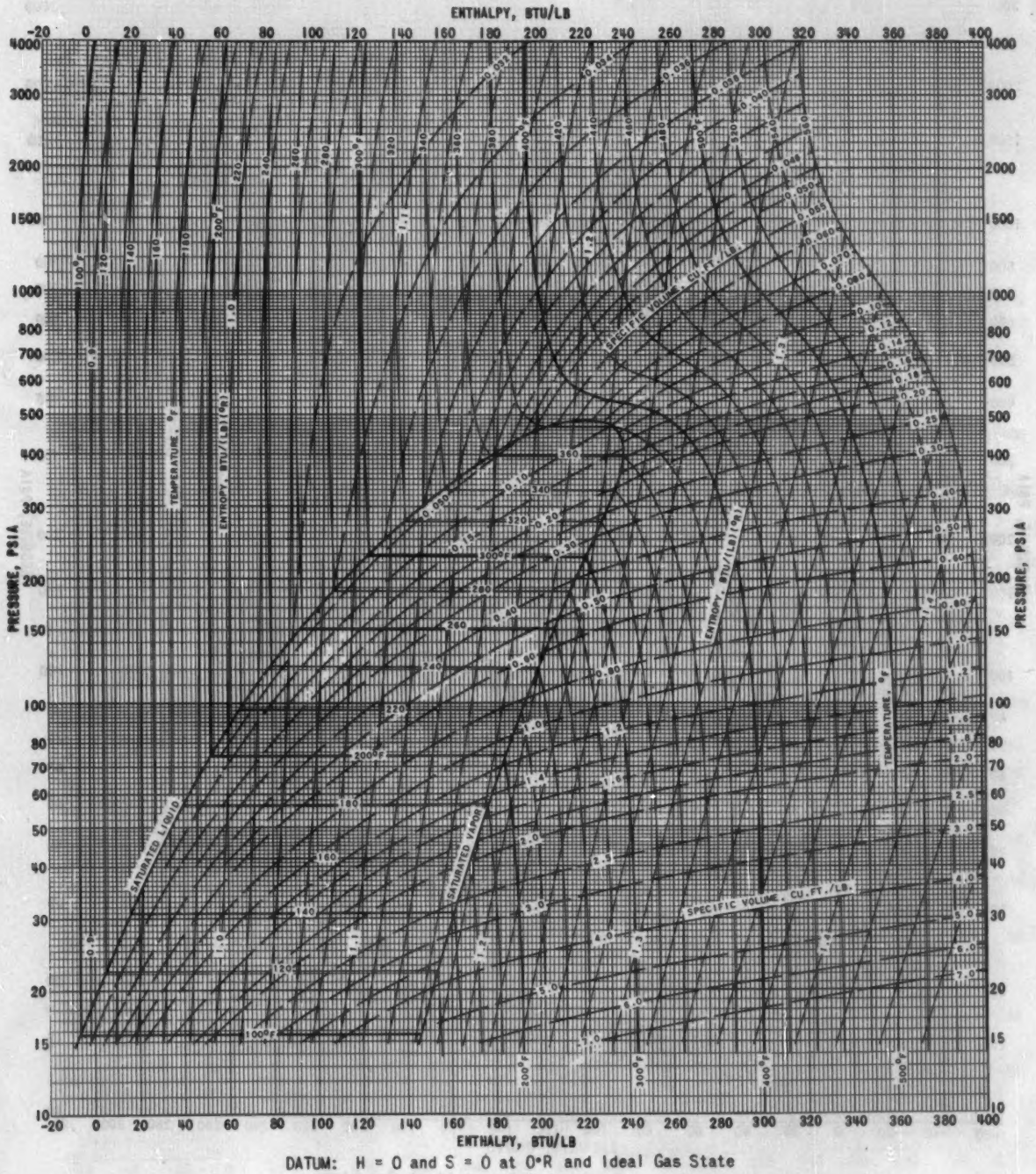


FIGURE 6.11—Mollier chart for n-pentane.

entropy and enthalpy are computed from P-V-T data.

This may be done by fitting an empirical equation of state to the P-V-T data and using this equation with the basic thermodynamic relationship to compute the pressure effects. Alternatively, this computation may be made by evaluating the thermodynamic relationships by graphical and/or numerical treatment of the P-V-T data. Sometimes a combination analytical and graphical procedure is employed. In this procedure the equation of state terms are computed and combined with results of graphical calculations made on the residual between the equation of state and the actual P-V-T data.

The saturated vapor curve is located from the vapor pressure versus temperature curve. Next the saturated liquid line is located by measuring the entropy or enthalpy of vaporization along the lines of constant temperature (and pressure). ΔS and ΔH for vaporization are computed from the vapor pressure and the densities of the saturated vapor and liquid.

This procedure was used in preparing the charts on which the present ones were based.

Previous Work. References to several previous Mollier chart publications are given at the end of this part. The charts published in earlier series in the PETROLEUM REFINER[5] were approximations as they were based on generalized correlations. They were presented to illustrate how such a chart could be prepared for a substance from its boiling point and critical conditions.

Mollier charts have been prepared for hydrocarbons by Dutch and USA authors. The work in Holland was done at the Kamerlingh Onnes Laboratory (KO), Leiden University. Methane, ethylene, ethane, propylene, propane, i-butane, and n-butane were covered. In addition, charts were made for oxygen, nitrogen, and helium. The work was done under the joint sponsorship of several European companies before World War II. Work ended during the war and except for preparing manuscript for publication was never resumed.

As brought out below in more detail, the KO hydrocarbon charts were used along with API 44 compilations in developing the new improved charts presented here.

Other data used in the evaluations of the new charts presented here were those for methane,[7] ethylene,[14] ethane,[1] propylene,[4] and n-butane.[9] Previously published[2] properties of n-pentane were used in preparing the n-pentane chart.

Other Mollier charts of interest are those for SO_2,[11] H_2S,[13] benzene,[8] and methyl alcohol.[12]

Evaluation of Mollier Charts. It is of interest to compare the alternate P-H diagrams, available from two sources, for five light hydrocarbons (methane, ethylene, ethane, propylene, and n-butane).

Essentially the same Mollier chart preparation procedures were used in making the charts from both sources. Entropy and enthalpy are computed independently of each other, checked for consistency, and then plotted. These calculations require the use of thermal or spectroscopic data for the effects of temperature at low pressure (ideal gas state) and P-V-T data for the effect of pressure at various temperatures.

The ideal gas state entropy and enthalpy values, i.e., S° and H°, compiled by API Research Project 44[10] have been widely accepted as being the most accurate and consistent tabulations of these thermodynamic properties available for hydrocarbons. These API 44 H° and S° values were not available for the earliest of these USA charts, but were for the later ones. Comparisons showed significant differences between the KO and USA chart H° values.

It was concluded that the API 44 H° and S° values should be used throughout in preparing the new charts, thus giving more consistency from chart to chart as well as better accuracy for the entropy and enthalpy values on each diagram. Comparisons on temperature effects are not included.

Three fundamental thermodynamic relationships are used to check internal consistency of enthalpy-entropy diagrams with the P-V-T data: (1) on log "P" versus "H" coordinates, the slope of the isentropes (lines of constant entropy) is equal to reciprocal PV, i.e.,

$$\left(\frac{\partial \ln P}{\partial H}\right)_S = \frac{1}{PV} \tag{6.1}$$

(2) on "H" versus "S" coordinates the slope of the isobars (lines of constant pressure) is equal to the temperature, i.e.,

$$\left(\frac{\partial H}{\partial S}\right)_P = T \tag{6.2}$$

(3) on log "P" versus "S" coordinates, the slope of the isenthalps (lines of constant enthalpy) is the product of the first and second slopes, i.e.,

$$\left(\frac{\partial \ln P}{\partial S}\right)_H = \frac{T}{PV} \tag{6.3}$$

Consistent units must be used throughout.

Equations 6.1 and 6.2 are of most interest because they apply to Mollier chart coordinates in actual use. Mollier charts having the coordinates of the third test, Equation 6.3 would not be practical because enthalpy readings cannot be made conveniently.

Entropy-temperature diagrams are used in work or refrigeration cycle calculations. On these coordinates the slope of the isobars is the heat capacity divided by temperature, i.e.,

$$\left(\frac{\partial S}{\partial T}\right)_P = \frac{C_P}{T} \tag{6.4}$$

where: C_P = heat capacity at "S" and "T" coordinates of slope. Equation 6.4 does not give a consistency check between P-V-T data and the T-S diagram but it does give a consistency check between the T-S diagrams and

a C_P versus "T" and "P" plot, if such has been prepared.

Referring to Equation 6.1, it can be seen that a negative slope of the isentropes on log "P" versus "H" coordinates is impossible because the PV product is always positive. Likewise, the isobars on an H-S diagram cannot have a negative slope, as can be readily seen by examining Equation 6.2.

Except for the higher pressure (above 40 atmospheres) region of the n-butane chart by Prengle et al.,[9] all the hydrocarbon charts examined satisfied the above internal consistency test.

A detailed comparison of the KO and USA hydrocarbon charts was made in 1951 by Canjar.[3] Comparisons included: saturated vapor enthalpy, heat of vaporization, isothermal effects of pressure on enthalpy at several temperature levels, and enthalpy difference for isentropic increase of pressure. In general, agreement was good, with the conclusion that the properties derived from P-V-T data for the KO charts were as good or better than the USA charts.

The high-pressure or subcooled liquid region is only found on the KO charts. The authors of these charts made the test given by Equation 6.1 for both liquid and vapor regions. Disagreement in the liquid region was as high as 5 percent of the reciprocal PV term and below 1 percent in the superheated vapor region.

Preparation of New Charts. The new charts presented here have been based on the API 44[10] ideal gas state thermal properties and, except for n-pentane, upon the volumetric correlations and derivations of the Kameringh Onnes Laboratory,[6] discussed above. This combination is believed to result in a set of improved charts. The n-pentane chart given here was redrawn from a chart and tables published recently by Brydon et al.[2] (Normal pentane was not covered by the KO Laboratory.)

Large plots (36 x 48 inches) of the KO data (metric units) were used. These were log "P" versus "H" diagrams with lines of constant temperature, entropy, and specific volume. The zero enthalpy datum was saturated liquid at one atmosphere, and the units were: temperature in °C or °K, pressure in atmospheres, enthalpy in calories per gram, entropy in calories per gram per °C, and specific volume in cubic centimeters per gram. The units and datum were changed in constructing the new charts. In making these changes the API 44 ideal gas state properties were substituted for the values of these properties that had been used in the original chart preparation by KO. Thus, only the effects of pressure on the thermodynamic properties were taken from the KO charts.

Constant temperature lines—The enthalpy values read from the KO charts were corrected to a new datum, i.e., zero enthalpy at O°R and O psia by the relation,

$$H_{corr} = H_{KO} - H^\circ_{KO} + H^\circ_{API\ 44} \qquad (6.5)$$

the resulting enthalpy values were converted to engineering units, and the corrected enthalpy values were plotted against temperature giving H-T charts. Readings from these charts determined the saturated vapor line and the lines of constant temperature for the P-H charts. The saturated liquid line was drawn to give the correct latent heats of vaporization.

Constant entropy lines—Entropy values from the KO charts were corrected to the new datum and units. An "H" versus "S" intermediate plot was prepared and from this the "H" and "P" coordinates of lines of constant even "S" values were read. The corrected entropy was obtained from the relation,

$$S_{corr} = S_{KO} - S^\circ_{KO} + S^\circ_{API\ 44} \qquad (6.6)$$

Equation 6.6 gave entropy values corrected to the standard state of unit fugacity and O°R.

The resulting entropy values were converted to engineering units and the corrected and converted entropy values were then plotted against enthalpies for different pressures. From this intermediate plot, the "P" and "H" coordinates were obtained for the lines of constant entropy on the final charts.

Constant volume lines—Specific volume values were read from the KO charts, crossplotted, for interpolating and smoothing, and then lines of constant specific replotted on the Mollier charts.

The P-H diagrams for the first three light hydrocarbons (methane, ethylene, and ethane) are presented on two parts. This was done to standardize on scales and chart size. The enthalpy scales were longer for these three hydrocarbons. For convenience in use, the two parts for each diagram overlap.

ACKNOWLEDGMENT

W. S. Hanna prepared the charts.

LITERATURE CITED

[1] Barkelew, C. H., Valentine, J. L., and Hurd, C. O., "Thermodynamic Properties of Ethane," Trans. Am. Inst. of Chem. Eng., 43, No. 1, p 25-38 (1947).

[2] Brydon, J. W., Walen, N., and Canjar, L. N., "Thermodynamic Properties of n-Pentane," Chem. Eng. Prog. Symposium Series, 49, No. 7, p 151-157 (1953).

[3] Canjar, L. N., Private Communication, December 1951.

[4] Canjar, L. N., Goldman, M. and Marchman, H., "Thermodynamic Properties of Propylene," Ind. and Eng. Chem. 43, No. 5, p 1186-1193 (1951).

[5] Edmister, W. C., "Applications of Thermodynamics to Hydrocarbon Processing, Part XVII Enthalpy-Entropy Plots for Pure Hydrocarbons" and Part XVIII "Enthalpy-Entropy Plots for Hydrocarbon Mixtures," Petroleum Refinery, March and April 1949.

[6] Keesom, W. H., Bijl, A., and Monte, L. A. J., J. App. Sci. Res. 4, Sec. A, p 261 (1952).

[7] Matthews, C. S., and Hurd, C. O., "Thermodynamic Properties of Methane," 42, No. 1, p 55-78 (1946).

[8] Organick, E. I. and Studhalter, W. R., "Thermodynamic Properties of Benzene," Chem. Eng. Prog. 44, No. 11, p 847-854 (1948).

[9] Prengle, H. W., Jr., Greenhaus, L. R., and York, R., Jr., "Thermodynamic Properties of n-Butane," Chem. Eng. Prog. 44, No. 11, p. 863-868 (1948).

[10] Rossini, F. D., "Selective Values of Properties of Hydrocarbons," API Research Project, Carnegies Institute of Technology, Pittsburgh, Pennsylvania.

[11] Rynning, D. F., and Hurd, C. O., "Thermodynamic Properties of Sulfur Dioxide," Trans. Am. Inst. of Chem. Eng. 41, p 265 (1945).

[12] Smith, J. M., "Thermodynamic Properties of Methyl Alcohol," Chem. Eng. Prog. 44, No. 7, p 521-528 (1948).

[13] West, James R., "Thermodynamic Properties of Hydrogen Sulfide," Chem. Eng. Prog. 44, No. 4 p 287-292 (1948).

[14] York, R., Jr. and White, E. F., Jr., "Thermodynamic Properties of Ethylene," Trans. of Am. Inst. of Chem. Eng. 40, No. 2, p 227-249 (1944).

Next, Part 7: Isentropic Exponents for Gases.

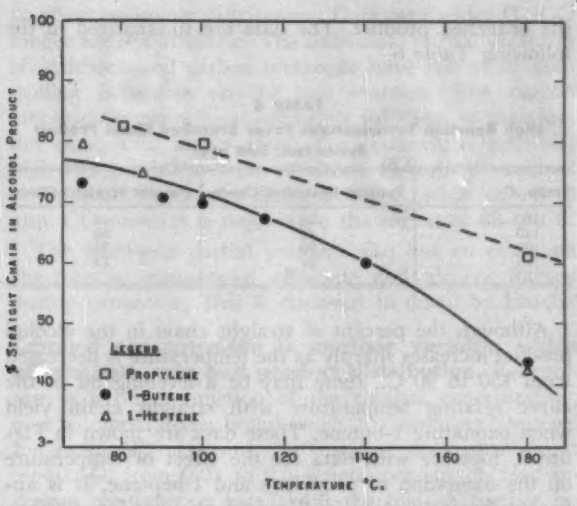


FIGURE 1—Low temperature favors straight chain product isomers. Notice that propylene gives a different temperature dependance than either 1-butene or 1-heptene.

These Variables Affect Oxo Reactions

Reaction rate and isomer distribution are affected by temperature, hydrogen and carbon monoxide partial pressure as well as catalyst concentration.

I. Kirshenbaum and V. L. Hughes
Esso Research & Engineering Co., Linden, N. J.

WELL OVER 75 million pounds of alcohols and aldehydes were probably produced in 1957 by the Oxo reaction. This reaction discovered in 1938, an industrial infant in 1948, is now a principal petrochemical process. In the Oxo reaction, CO and H_2 are reacted with an olefin to produce aldehydes, which are then reduced to alcohols. A number of different isomers are formed; for example, oxonation of 1-butane leads to two isomeric aldehydes or alcohols.

$$CH_3-CH_2-CH=CH_2 \xrightarrow[H_2]{CO} \begin{cases} CH_3-CH_2-CH_2-CH_2-CHO \xrightarrow{H_2} CH_3-CH_2-CH_2-CH_2-CH_2OH \\ CH_3-CH_2-\underset{CH_3}{CH}-CHO \xrightarrow{H_2} CH_3-CH_2-\underset{CH_3}{CH}-CH_2OH \end{cases}$$

Similarly, higher olefins give at least three principal isomeric products. Thus oxonating 1-heptene produces as principal products 1-octanol, 2-methyl-1-heptanol and 2-ethyl-1-hexanol.

The Oxo reaction is readily carried out in the presence of a cobalt catalyst* at 70-200 C., and 100-400 atm. of synthesis gas (H_2 and CO). The type of product obtained in the Oxo reaction depends upon operating conditions, as well as upon the type of olefins in the feed stock.

Most Oxo alcohols are produced commercially from mixed olefin streams and accordingly are themselves mixtures of alcohol isomers. The principal Oxo alcohols sold today are Isooctyl and Isodecyl, produced from C_7 and C_9 refinery olefins, respectively. An analysis of a typical Isooctyl alcohol is shown in Table 1.

When oxonating a mono-isomeric olefin stream such as 1-butene, the product is less complex, but nevertheless still a mixture of isomers. As stated previously, 1-butene gives t[illegible]omeric alcohols and 1-heptene gives three principa[illegible]someric alcohols. Table 2 lists the principal isomeric alcohols obtained from a number of different olefin feedstocks.[6]

Olefin type has a marked effect on both oxonation rate and product distribution. Terminal, straight chain olefins (such as 1-heptene) react most rapidly and the chain length is only of secondary importance. Moving the double bond away from the terminal position (e.g. 2-heptene) lowers the relative activity to about one-third at 110 C. Highly branched and cyclic olefins have the lowest reaction rates. The relative reactivities of several olefins, as determined by Wender and coworkers[7,8] are shown in Table 3.

As noted previously in Table 2, olefin isomers such as 1-heptene and 2-heptene give the same type of alcohols i.e. n-octanol, 2-methyl-1-heptanol and 2-ethyl-1-hexanol. However, the relative amounts of each isomer can be different, depending upon the oxonation temperature. At high temperatures (~ 170 C.) both isomers give about the same product distribution but at 95 C. there is a marked difference in the amount of straight chain isomer from the two olefins. Typical data are shown in Table 4.

TABLE 1
Isooctyl Alcohol Comprises Many Isomers

ISOMER	Structure	Weight Percent
3,4-Dimethyl-1-hexanol	$CH_3CH_2CH(CH_3)CH(CH_3)CH_2CH_2OH$	20
3,5-Dimethyl-1-hexanol	$CH_3CH(CH_3)CH_2CH(CH_3)CH_2CH_2OH$	30
4,5-Dimethyl-1-hexanol	$CH_3CH(CH_3)CH(CH_3)CH_2CH_2CH_2OH$	25
3-Methyl-1-heptanol...	$CH_3CH_2CH_2CH_2CH(CH_3)CH_2CH_2OH$	15
5-Methyl-1-heptanol...	$CH_3CH_2CH(CH_3)CH_2CH_2CH_2CH_2OH$	
Other Isomers.....	.....	10

* Practically any cobalt compound can be used since the cobalt is converted to cobalt carbonyl and/or hydrocarbonyl.

Variables Affect Oxo Reactions . . .

TABLE 2
Principal Oxo Alcohols from Mono-olefin Feedstocks

OLEFIN	ALCOHOLS
Propylene	n-Butanol 2-Methyl-1-propanol
1-Butene or 2-Butene	n-Pentanol 2-Methyl-1 butanol
Isobutylene	3-Methyl-1-butanol*
1-Pentene or 2-Pentene	n-Hexanol 2-Methyl-1-pentanol 2-Ethyl-1-butanol
1-Heptene or 2-Heptene	n-Octanol 2-Methyl-1-heptanol 2-Ethyl-1-hexanol
2,4,4 Trimethyl-1-pentene	3,5,5-Trimethylhexanol
Cyclohexene	Cyclohexylmethanol

* Also about 4% 2,2, Dimethylpropanol.

TABLE 3
Oxonation Rate Depends Upon Olefin Structure

OLEFIN	Rate ($k \times 10^3$ min^{-1})
1-Pentene	68.3
1-Heptene	66.8
2-Pentene	21.3
2-Heptene	19.3
2,4,4-Trimethyl-2-pentene	2.3
Cyclohexene	5.8

TABLE 4
Olefin Type Determines Product Distribution in Low Temperature Oxonation

Temperature C.	95 C		170 C.	
Olefin Product Alcohols, Weight Percent	1-heptene	2-heptene	1-heptene	2-heptene
n-Octanol	72	49	44	50
2-Methyl-1-heptanol	23	51	40	50
2-ethyl-1-hexanol	5		16	

Of all the process variables studied, temperature is most important for controlling both rate and product distribution. In laboratory tests, decreasing the temperature from 140 to 100 C. reduces the reaction rate in the oxonation of 1-butene by a factor of 25. Typical data as shown in Table 5.

TABLE 5
Temperature Dependence of Butene Oxonation
1-Butene Feed; 3500 psig.

Temperature C	Relative Reaction Rate
140	1.0
120	0.2
100	0.04
90	0.01

Product distribution also changes with temperature,[2,3] At 70-90 C., the yield of straight chain isomer comprises about 75 percent of the product from a 1-butene oxonation, whereas at 180 C. only 45 percent of the product is straight chain. Thus high reaction temperatures favor the branched product. The data are summarized in the following Table 6.

TABLE 6
High Reaction Temperatures Favor Branched Chain Product
1-Butene feed; 3500 psig.

Temp. C	Percent Branched Chain	Percent Straight Chain
180	55	45
140	40	60
90	29	71
70	27	73

Although the percent of straight chain in the alcohol product increases sharply as the temperature is decreased from 150 to 90 C., there may be a levelling off in the curve relating temperature with straight chain yield when oxonating 1-butene. These data are shown in Figure 1, together with data for the effect of temperature on the oxonation of propylene and 1-heptene. It is apparent from the data in Figure 1 that propylene gives a different temperature dependence than either 1-butene or 1-heptene. There are theoretical reasons for this difference, as discussed in another paper.[2] From the data in Figure 1 it is apparent that there is little advantage to oxonating below the 70-90 C. region when straight chain compounds are the desired product, especially since oxonation rates are normally low at these low temperatures.

As noted previously either aldehydes or alcohols can be produced by the oxo reaction. Low temperatures favor the selectivity to aldehydes. However, according to Hatch[4] aldehyde yields are a maximum at about 110-140 C. This temperature range is a compromise between lower reaction rates at lower temperatures and increased by-product formation and hydrogenation of the aldehyde at higher temperatures.

The rate of the Oxo reaction is pressure dependent but as shown by the following rate equation, the dependence is a function of both H_2 and CO partial pressures.[5,6]

$$\text{Initial Rate} \propto \frac{k P_{H_2}}{k' P_{CO} + k'' P_{H_2}}$$

Thus the rate of oxonation increases with increasing H_2 pressure and decreases with increasing CO pressure (at constant H_2 pressure). If, however, the P_{H_2}/P_{CO} ratio is kept constant, the oxonation rate is pressure independent over a relatively wide pressure range.

Total pressure has little effect on the product distribution as long as relatively high pressures are maintained. However, low pressures (less than 1000 psig.) result in products containing significantly lower amounts of the straight chain isomer. This is shown by the data in Table 7.

TABLE 7
Effect of Pressure of Alcohol Isomer Distribution
1-Heptene, 0.5 Weight Percent Cobalt/Olefin; 85 C; 3/1 H_2/CO Mole Ratio

Total Pressure, Psig.	600	3500	5000
Alcohol Composition			
Percent Straight Chain	45	75	75
Percent Branched Chain	75	25	25

Varying the H_2/CO ratio in the range of 1/1 to 4/1 has

no effect on isomer distribution. Data over wider H_2/CO ranges are not available. The individual partial pressures of hydrogen and carbon monoxide have two other controlling influences on the oxo reaction. The carbon monoxide pressure must always be sufficient to maintain the catalyst in stable form. For instance, a relatively high CO partial pressure of about 40 atm. is required to maintain the catalyst stable at 150 C. while only 8-10 atm. CO pressure is required in the region of 80-110 C.

The hydrogen partial pressure also has an effect on the relative amounts of aldehyde and alcohol formed during oxonation. This is discussed in detail by Hatch.[4]

Catalyst concentration is another variable which affects both rate and product distribution. Reaction rate is a direct function of the catalyst concentration, over a comparatively broad range. In oxonating 1-butene, for example, increasing the catalyst concentration at 90-100 C. from 0.05 to 0.5 weight percent on feed increases the reaction rate about ten fold. A further increase in catalyst concentration to 1.6 weight percent cobalt on feed at 100 C. resulted in a reaction rate comparable to that normally obtained at about 150 C. with a much lower catalyst concentration of 0.1-0.3 percent cobalt. However, increasing the catalyst concentration decreases the yield of straight chain product. This adverse effect of high catalyst concentration on yield of straight chain product may be seen from the data in Table 8 obtained with 1-heptene feed at 70-85 C.

TABLE 8

High Catalyst Concentration Favors Branched Chain Isomers

1-Heptene; 3500 psig.

Temperature, C	70		85	
Weight Percent CO (on Olefin)	0.5	2.0	0.5	2.0
H_2/CO Mole Ratio	3/1		1/1	
Alcohol Composition				
Percent Straight Chain	80	68	75	48
Percent Branched	20	32	25	52

From these data it would appear that low catalyst concentrations are necessary, when products containing predominantly the straight chain isomer are to be obtained in a low temperature oxonation reaction.

Conversion level has no effect on isomer distribution in the product alcohol. This is shown by recent laboratory data obtained with 1-heptene at 85, 100, and 170-180 C.[2] The range of conversions studied was 25-95 percent. As is evident from the data in Table 9, the yield of straight chain isomer does not vary significantly with conversion at either low or high temperatures.

TABLE 9

Effect of Temperature on Olefin Distribution

92 Percent 1-Heptene as Olefin Feed, 3500 psig of 1/1 H_2/CO

Temp. C.	85		100		170-180 (a)	
Conversion, Mole Percent	Type I/II Olefin, Mole Percent	Alcohol Percent St. Chain	Type I/II Olefin, Mole Percent	Alcohol Percent St. Chain	Type I/II Olefin, Mole Percent	Alcohol Percent St. Chain
25	100/0	78 (b)	—	—	—	—
34	—	—	84/16	—	10/90	49
50	88/12	76	64/36	—	9/91	44
72	—	—	20/80	—	9/91	49
84	—	—	10/90	—	—	—
88	—	—	—	—	5/95	45
95	—	75	—	72	—	45

(a) Isothermal conditions could not be maintained due to exothermic nature of reaction.
(b) 100 percent 1-heptene was used in this experiment.

The data in Table 9 show that olefin isomerization occurs during the oxonation reaction. Heptene-2 is produced at all conversion levels and at both high and low temperatures. The olefin isomer distribution, however, changes slowly at low temperatures but rapidly at high temperatures. At 170-180 C., the 1-heptene/2-heptene ratio is 10/90 at a 34 percent conversion level. It remains essentially constant throughout the rest of the reaction. These observations have theoretical significance[2] and explains why 1-heptene and 2-heptene give the same isomer distribution in 180 C. oxonations.

In conclusion, available data show that two variables are primarily responsible for the isomer distribution of an Oxo alcohol produced from a straight chain olefin. These are the reaction temperature and the position of the double band in the olefin. From an operational standpoint, the important variables for determining reaction rate are temperature and H_2 or CO partial pressure. These variables also affect the relative yields of alcohols vs. aldehydes in the synthesis step of the Oxo process.

The mechanism of the Oxo reaction is quite complex. It probably proceeds through formation of an intermediate complex formed between the olefin feed and the cobalt carbonyl or hydrocarbonyl catalyst. Different olefin isomers form different complexes and it is believed that this difference in complex structure accounts for differences in oxonation rates and product distributions. These theories are discussed in detail in a number of published papers.[2,7,8]

LITERATURE CITED

[1] Martin, A. R., Chem & Ind 50, 1936 (1954).
[2] Hughes, V. L. and Kirshenbaum, I., paper presented at 131st Meeting of the American Chemical Society, Miami, April, 1957 also Ind. Eng. Chem. December 1957.
[3] Goldfarb, I. J. and Orchin, M. Preprint of the First International Congress on Catalysis, Philadelphia, September 1956.
[4] Hatch, L. F. "Higher Oxo Alcohols" John Wiley and Sons, N. Y., 1957.
[5] Natta, G., et al. *J. Am. Chem. Soc.* 76, 4049 (1954).
[6] Wender, I., Petroleum Refiner, 35, 197 (1956).
[7] Wender, I., Greenfield, H., and Sternberg, H. W., paper presented at the 125th Meeting, American Chemical Society, Kansas City, Mo. (1954).
[8] Wender, I., Metlin, S., Ergun, S., Sternberg, H. W. and Greenfield, H., *J. Am. Chem. Soc.* 78, 5401 (1956).

About the Authors

Kirshenbaum

Isidor Kirshenbaum received his B.S. degree in 1938 from City College of New York and his Ph.D. degree in 1942 from Columbia University. During World War II, Dr. Kirshenbaum was with the Manhattan Project. He joined the Esso Research and Engineering Co. in 1945, where he has worked primarily in the field of catalysis and until recently, headed a group doing research on chemical processes including Oxo. He is a Research Associate in the Technical Information Division. Dr. Kirshenbaum is a member of numerous technical societies.

Hughes

Vincent L. Hughes received his B.S. degree in 1948 from Providence College and was awarded his Ph.D. degree from Clark University in 1954. He joined the Chemicals Research division of the Esso Research and Engineering Co. in 1954, where he has worked primarily in the field of Oxo reactions and now heads a group doing research in the petrochemicals field. Dr. Hughes is a member of the American Chemical Society and Sigma Xi.

Know Your Asphalts – Part 10

Road Oils or Cut-Backs

E. J. Barth
Asphalt Consultant
New York City

ROAD OILS are a means of supplying bituminous binder to roads without using high temperatures to liquefy solid or semi-solid asphalts. Road oils are actually diluted solid binders, often called cut-backs, since these binders are cut-back with a distillate of proper type.

There are three large classes of road oils: rapid-curing oils (RC), medium curing (MC) and slow-curing (SC) type of oils. These grades are manufactured by blending hot solid or semi-solid asphalt with

(1) Crude petroleum naphtha for RC grades;
(2) Untreated kerosines for MC grades, and
(3) A heavy, or light gas-oil for SC grades.

Each distillate is mixed by hot blending with the asphalt. Blending is in modern metered equipment, electronically controlled to produce exact viscosity. After blending the material is pumped to storage, at only slightly elevated temperatures.

Road oil manufacture requires careful control, especially of the distillates and the base stock. Base stocks are often soft asphalts of definite test, usually straight or vacuum run oil asphalts of proper type and solubility. Road oils can be made with base asphalt as hard as 30 or 40 penetration, or with blown oxidized asphalts.

The distillates must pass rigid distillation tests—initial and end boiling points, open or closed flash points, and volatility. The SC groups require a distillate which does not carry or produce asphalt upon oxidation, or contain deleterious waxy or sludge components.

Keep in mind that a road oil is merely a diluted solid binder. The binder is important on the road, and distillates which only thin down this binder eventually evaporate, and contain no material adversely affecting the nature of the binder.

Depending on correctly graded distillates, rapid drying times are obtained for the Rapid Curing Road Oils, allowing road traffic within a few hours after oiling. The Medium Curing Oils, using less volatile kerosine will dry or "cure" somewhat slower, allowing a more thorough penetration of the liquid into the pavement aggregate, before final evaporation. With Slow Curing Road Oils, some grades are still in the final drying stage after one year. However at that time the binder has well set, and will perform its adhesive duty long after some solid binders have already shown degrees of hardening.

The speed of drying or "Curing" of various grades has received more attention in recent years due to studies by highway laboratories. Some investigators have formulated rates of curing based on various distillation tests. Film studies of liquid and solid binders on the aggregate would serve to further such studies.

Each of the above grades have six varieties, varying according to the viscosity of the blend. Each blend is made with various weight quantities of base asphalt to give a series of light or low, medium, and heavy types.

It is also most important to determine at the refinery that each distillate and asphalt base are compatible. The base asphalt should preferably be of negative Oliensis spot test. Base asphalts containing cracked material have been used by some states, as well as 100 percent cracking coal tars, which are cut back with distillates free from waxes, etc., for the SC grades.

Road oils are tested by removing various percentages of the distillates and testing the remaining base asphalts for their compliance with state highway specifications. Volatility of the oil is controlled by compliance of certain distillation specifications. In the condensed table below are shown three of the six grades of each of the three types of road oils.

Condensed Road Oil Specifications

	RC OILS			MC OILS			SC OILS		
GRADE	RC 0	RC 2	RC 5	MC 0	MC 2	MC 5	SC 0	SC 2	SC 5
Flash, Min.	—	80 + F.	80+	100+	150+	150+	150+	175+	250+
Viscosity:									
77 F.	*75–150	—	—	75–150	—	—	75–150	—	—
122 F.	—	—	—	—	—	—	—	—	—
140 F.	—	100–200	—	—	100–200	—	—	100–200	—
180 F.	—	—	300–600	—	—	300–600	—	—	300–600
Residue by Distillation Total Distillate to 680 F.	50%+	67%+	82%+	50%+	67%+	82%+	15–40%	5–25	5—
100 Pen. Asphalt Residue (Evaporation)	—	—	—	—	—	—	40+%	60+%	80+%
Asphalt Residue (Dist.)	80–120 Pen. 100 + Ductility			120–300 Pen. 100 + Ductility			100 + Ductility		
Asphalt Residue (Evap'n.)	—	—	—						

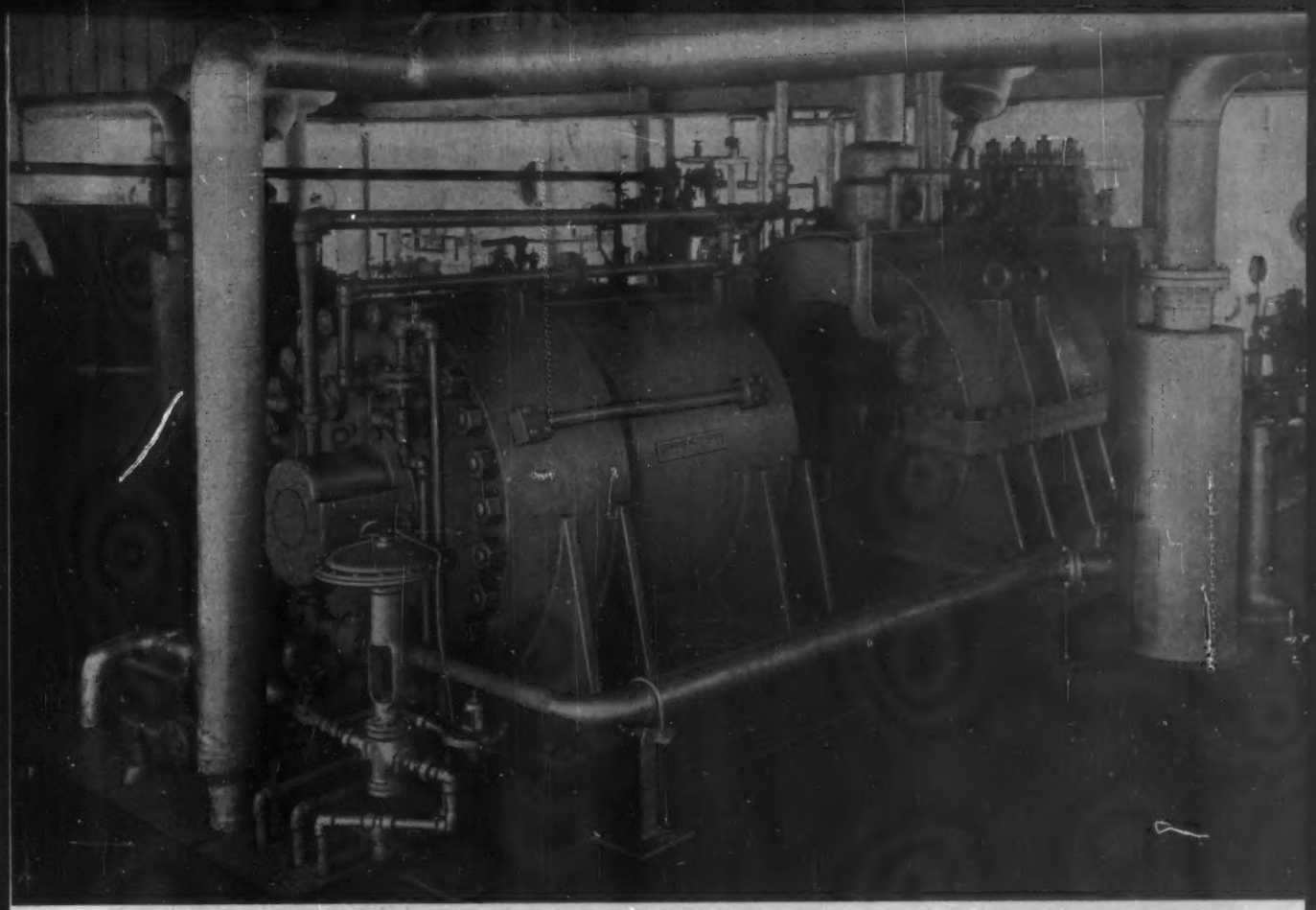
* Furol instrument.

Application temperatures for use on roads varies considerably with location. Below are average spraying and mixing temperatures as recommended by the Asphalt Institute:

	For Spraying	For Mixing
RC-0, MC-0, SC-0	85 F.	85 F.
RC-2	150	120
RC-5	240	180-200
MC-2	160	150
MC-5	250	225
SC-2	180	180
SC-5	240-250	290

About the Author

Edwin J. Barth, asphalt consultant in New York City, has had 40 years experience in asphalt manufacture in the United States and abroad. He has served as bituminous technologist with several major oil companies and has done much research work on asphalts and modern paving technology, applying new concepts in asphalt rheology. Barth is a licensed professional engineer, and a former asphalt consultant for Gulf Oil Company. He is a graduate of Columbia University where he received his B.S. degree in chemical engineering.

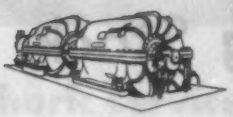


Putting the PRESSURE

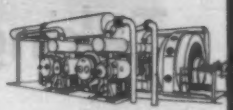
on low-grade naphthas to make high octane blending stocks

THE Ingersoll-Rand centrifugal compressor shown here handles hydrogen gas at high pressure — 5050 cfm at 675-psia discharge pressure. Driven by a 6340-hp I-R steam turbine, it is one of two duplicate machines installed as recycle compressor on a large catalytic reforming unit. This same refinery uses 19 additional I-R compressors.

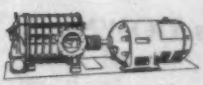
Ingersoll-Rand compressors are industry's first choice for high-pressure operation. Centrifugal compressors like the one shown here are now operating at pressures over 2,000 psi; I-R reciprocating compressors have been sold for pressures as high as 35,000 psi. So if your process calls for *putting on the pressure* you'll want to look into the complete line of I-R compressors. There's one that will be *just right* for your application. If necessary, a compressor can be designed specially for your application. Ask for your copy of form 3132-A, Process Compressors.



CENTRIFUGAL



RECIPROCATING



AXIAL-FLOW ROTARY

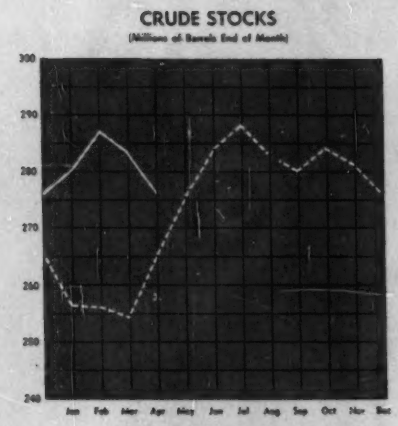
EJECTOR-JET

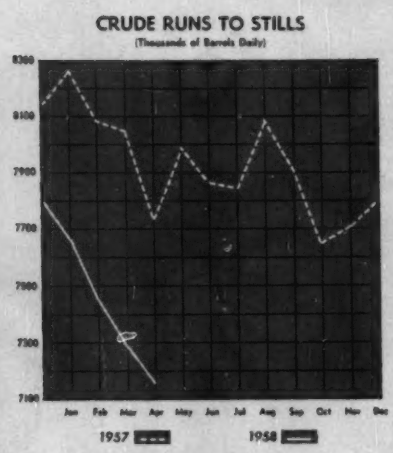
The World's Most Complete Line of Compressors

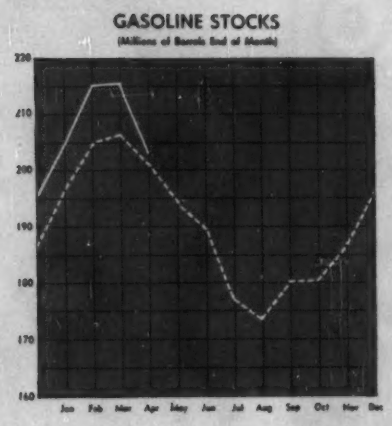
Ingersoll-Rand

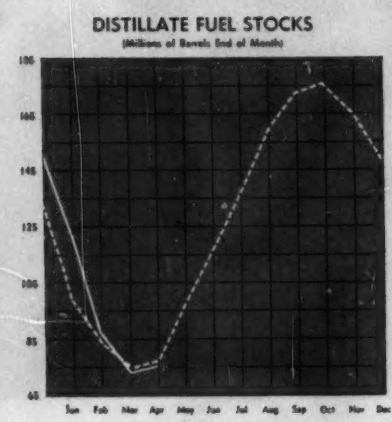
12-720 11 Broadway, New York 4, N. Y.

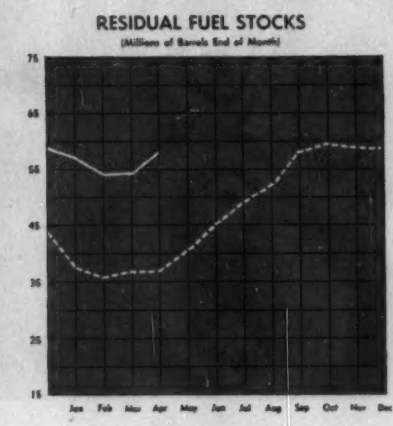
PUMPS • COMPRESSORS • DIESEL ENGINES • AIR & ELECTRIC TOOLS • TURBO BLOWERS • CONDENSERS

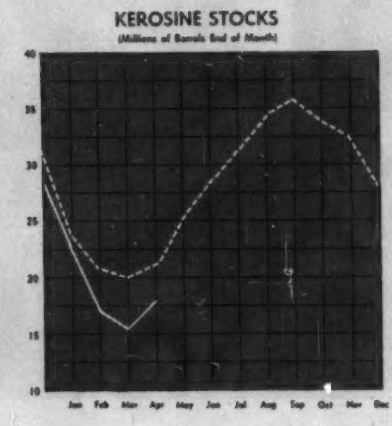












Taking Stock

- Crude stocks DOWN
- Crude runs DOWN
- Gasoline stocks DOWN

U. S. Monthly Oil Trends

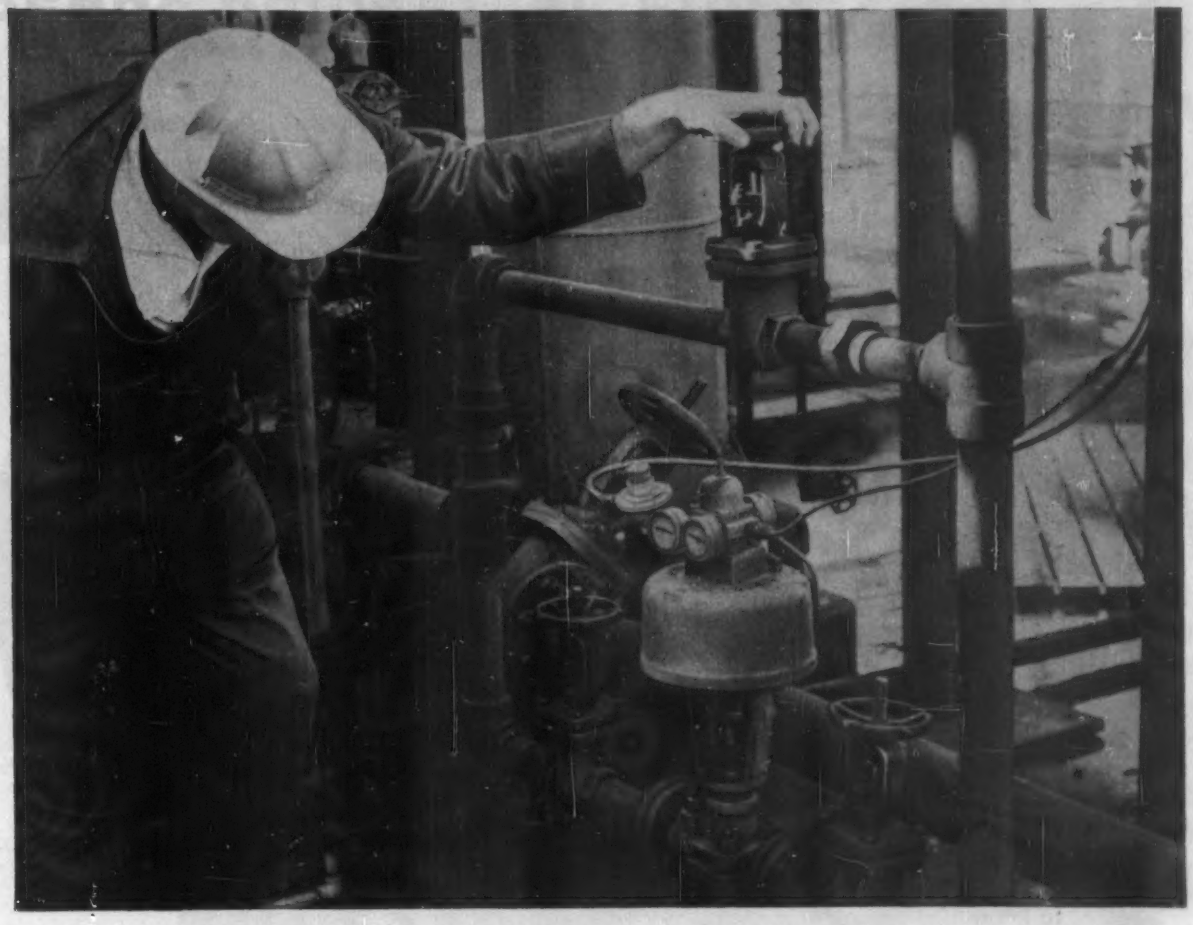
(THOUSANDS OF BARRELS DAILY)

	APRIL			March	JANUARY-APRIL		
	1958	1957	% Diff.	1958	1958	1957	% Diff.
U.S. Crude Oil Production	6,240	7,541	—17.3	6,273	6,543	7,604	—14.0
U.S. Nat. Gas Liquids Prod.	800	822	— 2.7	826	806	830	— 2.9
U.S. Total Imports	1,486	1,542	— 3.6	1,464	1,618	1,466	+10.4
East Coast Crude Imports	754	668	+12.9	882	796	625	+27.4
Total Crude Imports	891	906	— 1.7	1,033	948	832	+13.9
Total Refined Products	595	635	— 6.3	560	670	633	+ 5.8
Total New Supply	8,526	9,904	—14.0	8,666	8,967	9,899	— 9.4
Stock Changes All Oils (Daily)	—334	+490	.....	—580	—759	—418	.....
Total Demand All U.S. Oils	8,860	10,317	—14.1	9,246	9,718	10,317	— 5.8
Gasoline Demand	4,043	3,955	+ 2.2	3,617	3,669	3,751	— 2.2
Distillate Fuel Demand	1,583	1,709	— 7.4	2,125	2,349	2,434	— 3.5
Residual Fuel Demand	1,384	1,707	—18.9	1,464	1,645	1,875	—12.3
Domestic Demand, All Oils	8,630	8,606	+ 0.3	9,016	9,474	9,410	+ 0.7
Export Demand, All Oils	230	809	—71.6	230	244	907	—73.1
Crude Runs U.S. Refineries	7,160	7,740	— 7.5	7,297	7,413	8,038	— 7.8
Domestic Crude Runs	6,301	6,877	— 8.4	6,398	6,507	6,877	— 5.4
Foreign Crude Runs	860	863	— 0.4	899	905	824	+ 9.8

	TOTAL U.S. STOCKS Millions of Barrels End of Month				STOCKS EAST OF CALIFORNIA Millions of Barrels End of Month			
	April			March	April			March
	1958	1957	% Diff.	1958	1958	1957	% Diff.	1958
Crude Oil	276.0	265.8	+ 3.8	283.9	237.1	235.0	+ 0.9	240.3
Gasoline	203.3	201.4	+ 0.9	215.6	175.0	174.1	+ 0.5	186.9
Distillate Fuel Oil	76.0	78.7	— 3.4	74.8	64.4	69.1	— 6.8	62.3
Residual Fuel Oil	58.0	37.4	+55.1	54.9	26.8	25.3	+ 5.9	25.5
Kerosine	18.6	21.5	—13.5	15.5	18.3	21.1	—13.3	16.7

Source: Except for latest two months, all data from U.S. Bureau of Mines. Data for last two months from American Petroleum Institute weekly reports and U.S. Bureau of Mines weekly crude stock report; except U.S. Natural Gas Liquids Production and Demand figures which are estimated by World Oil.

Texas City Refining Inc. cuts valve replacement cost 500% plus



"Craneloy 20" valves on sulphuric service outlast valves formerly used 6 to 1

Handling sulphuric acid in varying concentrations is tough service for any valve.

At this Texas City, Texas, refinery, valves used on lines from sour water strippers never lasted more than 6 months. It was a case of "install today . . . replace tomorrow."

Three years ago, "Craneloy 20" gates were selected for this service. These high-nickel, high-chromium stainless valves, with rotating split-wedge disc seating, have given trouble-free service ever since. No leakage, no galling or seizing; and always operating smoothly.

To date, "Craneloy 20" valves have outlasted the other make valves 6 to 1—better than a 500% saving in replacement and maintenance cost.

If you're having trouble with valves on sulphuric acid or similar corrosive fluids, your Crane Representative has all the information on the "Craneloy 20" line.

Bring yourself up to date on corrosion-resistant alloy valves. Send for this Crane Circular AD-2080 today.

CRANE VALVES & FITTINGS

PIPE • PLUMBING • KITCHENS • HEATING • AIR CONDITIONING

Since 1855—Crane Co., General Offices: Chicago 5, Ill. Branches and Wholesalers Serving All Areas

Valuable Reading Ahead

Here's a quick run-down on what's presented in this month's non-technical sections. These departments will keep you right up-to-date with what's new and different in this rapidly changing oil industry.

Read What's Happening

"What's Happening In the Industry" is an accurate presentation of the items that made the news last month. The clear and concise manner in which the events are reported is just what's needed by busy industry men who don't have time to wade through unimportant details to reach the meat of the subject. And, when you come to the end of this section, you'll find "Changing Times" a list of rapid-fire news flashes that provide the final touch for keeping you informed. Now is the time to read "What's Happening In the Industry."

Keep Going to Page 263

Up the Ladder

Yes, each month hundreds of the industry's men go "up the ladder"—the promotion ladder, that is. New jobs are opened—old jobs are filled by new men, and you may know many of them. Take a look at "What's Happening Among Men in the Industry" to see what's happening to the men you know, and those you would like to know.

Keep Going to Page 282

Knowledge Is the Key

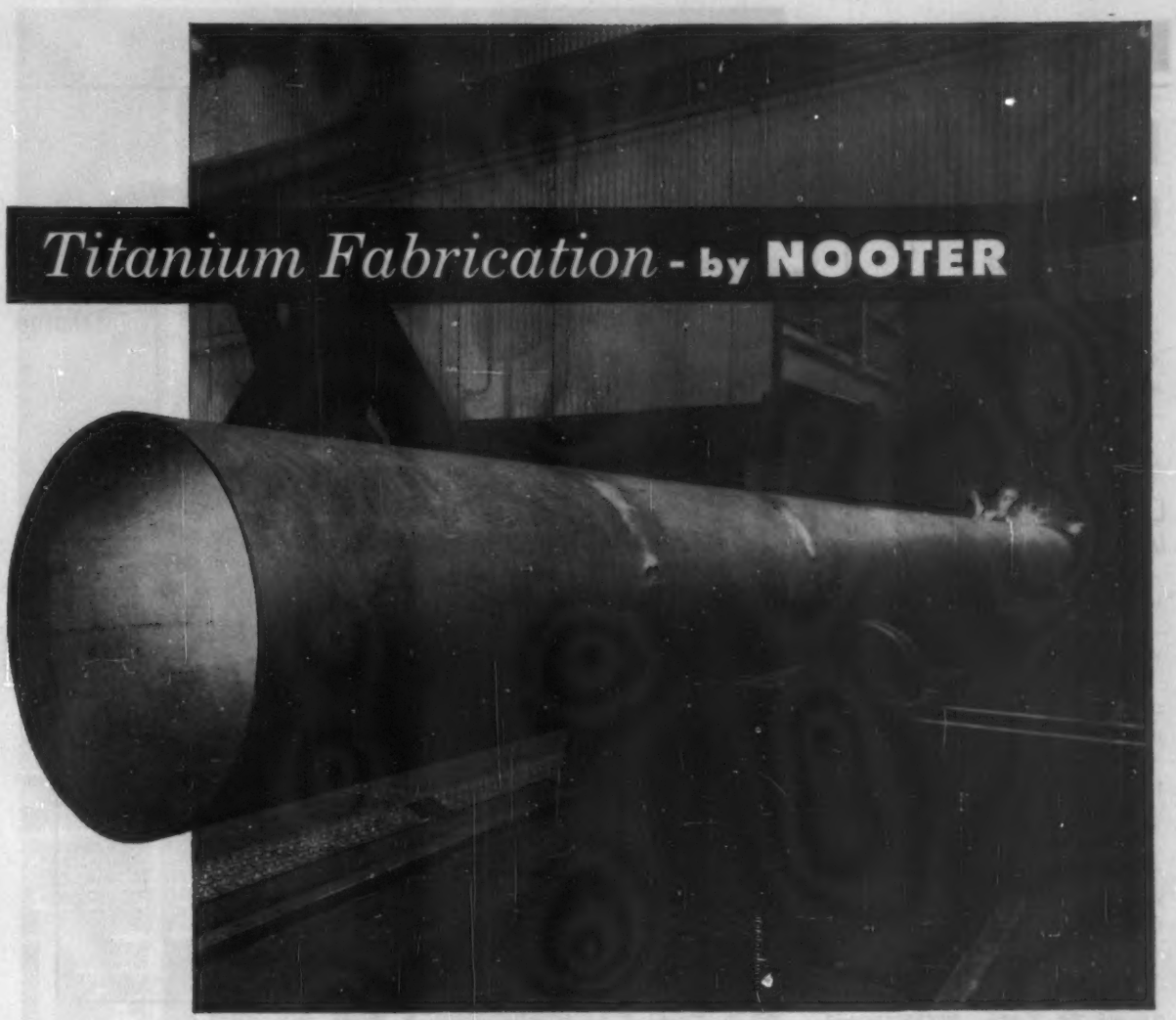
Knowledge is the key to success, at least one of them. And what better way is there to help you gain the knowledge you need to advance than through a good book on a subject important in the industry. You can learn about some of the better books by reading this month's "Reviewing New Books."

Keep Going to Page 319

A Refining Hall of Fame

Among the special features in PETROLEUM REFINER's special Oil Centennial Issue coming up in January, 1959, will be a Refining "Hall of Fame" honoring those 15 or 20 individuals who have contributed the most to the Oil, Gas and Petrochemical processing industry. Like we said in the April PETROLEUM REFINER, (page 164) we want each reader to submit the name of the one man he thinks has contributed the most to this industry. There are no special rules—if you think a man should be nominated, just let us know about it. All you have to do is write his name on the special postage-paid postcard just opposite page 335 of this issue. From these nominations, the final choice will be made for the Refining "Hall of Fame."

Keep Going to Page 335



And the RARER METALS

...can be put effectively and precisely to work for you by Nooter.

Such metals as . . . zirconium, tantalum, titanium. Metals with the capacity to withstand high temperatures and to resist corrosion. Metals with these and other special capabilities to meet the ever-increasing special demands of our very special age. And now at your disposal . . .

Nooter can and is now welding any type of zirconium, tantalum, or titanium plate fabrication . . . with single or multiple pass welding, fully X-rayed. In titanium work, the metal can be either commercially pure, or in some alloyed forms.

The welding and fabrication of these new metals is a pioneering task, exacting the highest skill and ingenuity from those who would unlock and put to use their special capabilities. It is not a new role for Nooter, with more than a half-century of experience as a custom fabricator. Through continuous, painstaking and imaginative metallurgical, fabricating, and welding research, Nooter over the years has led the way in developing techniques for working and welding many new metals and alloys.

And now...the RARER METALS! **When they fit your needs, let Nooter put them to work for you.**

NOOTER CORPORATION

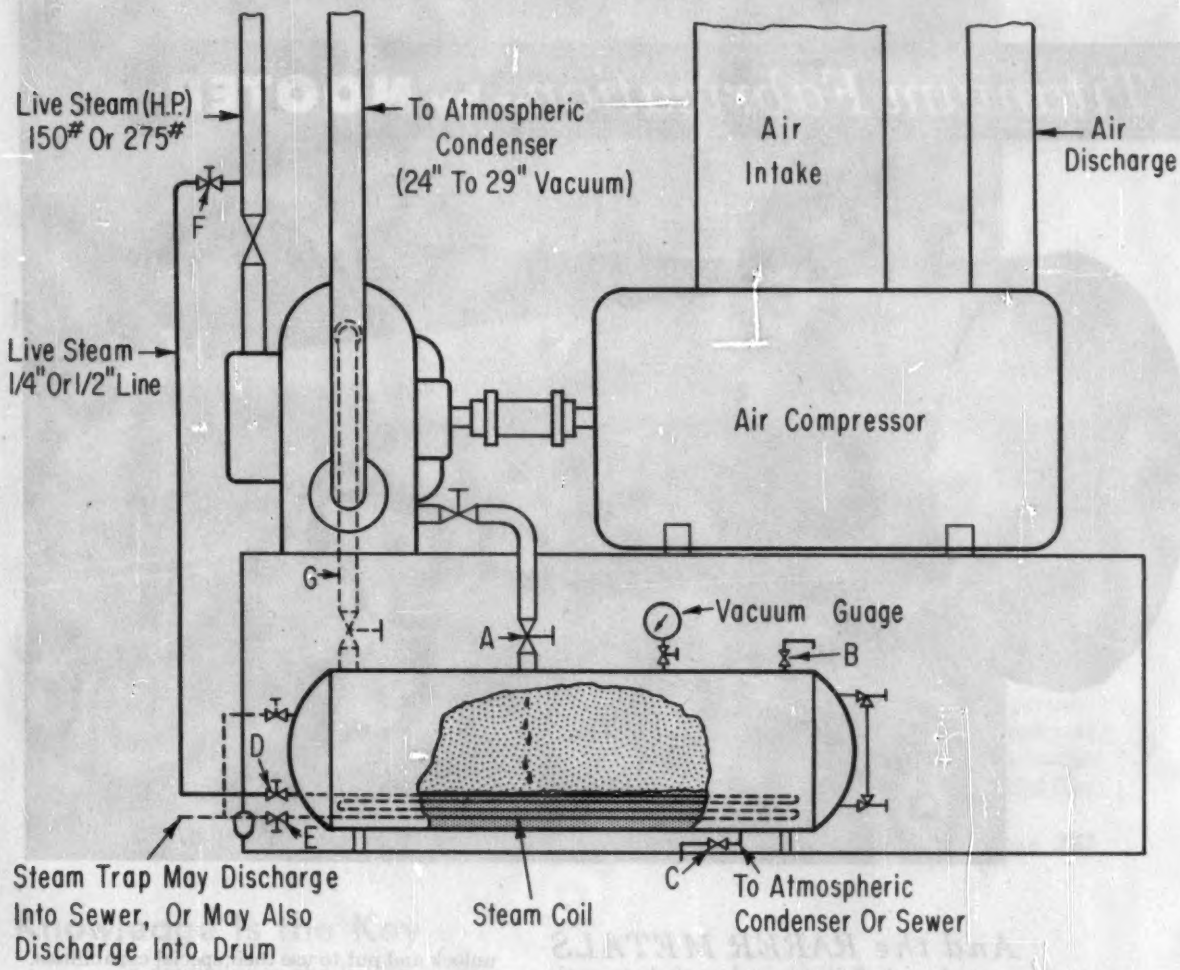
"Since 1896" NOOTER

Steel and Alloy Plate Fabricators and Erectors . . . "Boilermakers"

1404 SO. SECOND ST. • ST. LOUIS 4, MO.

For more data on advertised products, use Readers' Service Cards, last page.

How To Do It . . .



How to Make a Steam Condensate Reboiler

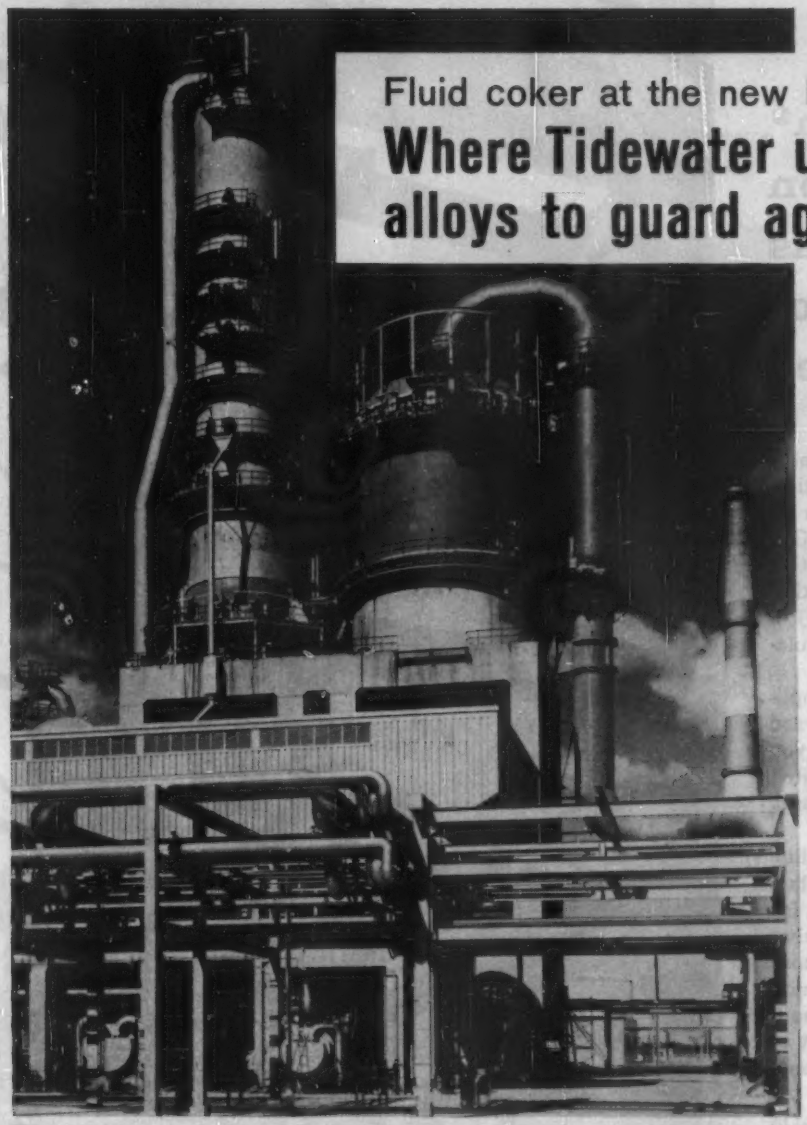
Do you want to free a man from ten to twenty minutes of minor work every hour for other duties? Here's how we did it. Because of the great amount of condensate from the steam turbines driving our turbo-blowers, it was necessary to drain the condensate drum manually twice an hour.

To eliminate this time consuming task, I reasoned that if water will boil at a low temperature, under a vacuum, then why not heat it and make steam again so that the vacuum can be used to eject it automatically from the drum. In other words, make a steam condensate reboiler for turbines that discharge into atmospheric condensers.

The connection is made as shown. For automatic operation, close valves B and C, open valves D, E and F. When E gets hot, open valve A and all of the condensate from the water logged turbine will drop into the bottom of the drum. The steam coil adds just enough heat to cause the condensate to flash into steam at a low temperature because of the vacuum. The steam is pulled back through valve A by the vacuum on the discharge line of the turbine. In some cases, line G may be required.

To operate the system manually, close valve A and open valves B and C. The line from C may be run either to the atmospheric condenser or to the sewer.

This condensate reboiler has been



Fluid coker at the new Delaware Refinery...

Where Tidewater uses high nickel alloys to guard against corrosion

Here's the fluid coker at the Tidewater Oil Company's new Delaware Refinery, which boasts the world's largest initial capacity.

Like other units in this refinery, the fluid coker reflects latest practice in economical corrosion protection. To provide this protection, Tidewater engineers took full advantage of the properties of high nickel alloys. You'll find the details in the table below.

Throughout this ultra-modern refinery, high nickel alloys such as Monel* and Inconel* combat corrosion by mineral acids and other troublesome corrosives.

For more information, or for help with a corrosion engineering problem of your own, write Inco's Development and Research Division.

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall St. New York 5, N. Y.

INCO
TRADE MARK

Schedule of Use of Monel nickel-copper alloy to combat corrosion by aqueous H_2S and HCl in fluid coker at the new Tidewater Refinery**

	EQUIPMENT	LOCATION	MATERIAL
Columns:	Fractionator	Top head	Monel-clad steel
		Shell, tray #17 to top	Monel-clad steel
		Trays #17, 18, 19	Monel alloy
Vessels:	Fractionator-accumulator	Nozzles	Monel alloy
	First commingler drum	"	" "
	Second commingler drum	"	" "
	Stabilizer accumulator	"	" "
	Blowdown quench drum	"	Monel alloy
	Main water seal vessel	"	" "
	Bypass water seal vessel	"	" "
Pumps:	Foul water pump	Casing, impeller	Monel alloy
Piping:	Foul water line, accumulator to stripper		Monel alloy

*Registered trademark **Where temperatures go above 500°-550°F, nickel-containing type 316 stainless and stainless-clad steel are also extensively used in this unit.

INCO NICKEL ALLOYS

Snap*On® pipe insulation specified as result of TEVA survey

TEVA (Thermo-Economic Value Analysis) is Gustin-Bacon's analytical approach to your pipe insulation requirements. TEVA compares G-B Snap*On, the one-piece pipe insulation molded of fine glass fibers, with other insulations *for your particular job.* Thermal efficiency of different insulations . . . wall thickness required . . . initial and operating savings . . . application conditions—all are analyzed and comparisons made to help you select the insulation best suited to the job at hand.

TEVA surveys reveal some startling advantages of Snap*On one-piece glass fiber pipe insulation. At one plant, for example, engineers determined that 1½" Snap*On was thermally more efficient than 2" of another insulation —and that they could save more than $10,000 on the cost of insulating material alone!

You'll soon discover that Snap*On has the highest thermal efficiency of any general-purpose pipe insulation up to 350° . . . that it is far easier and cheaper to apply because 3-ft. or 6-ft. one-piece sections simply snap on pipe. It's available for hot or cold lines, plain or jacketed, in sizes up to 33".

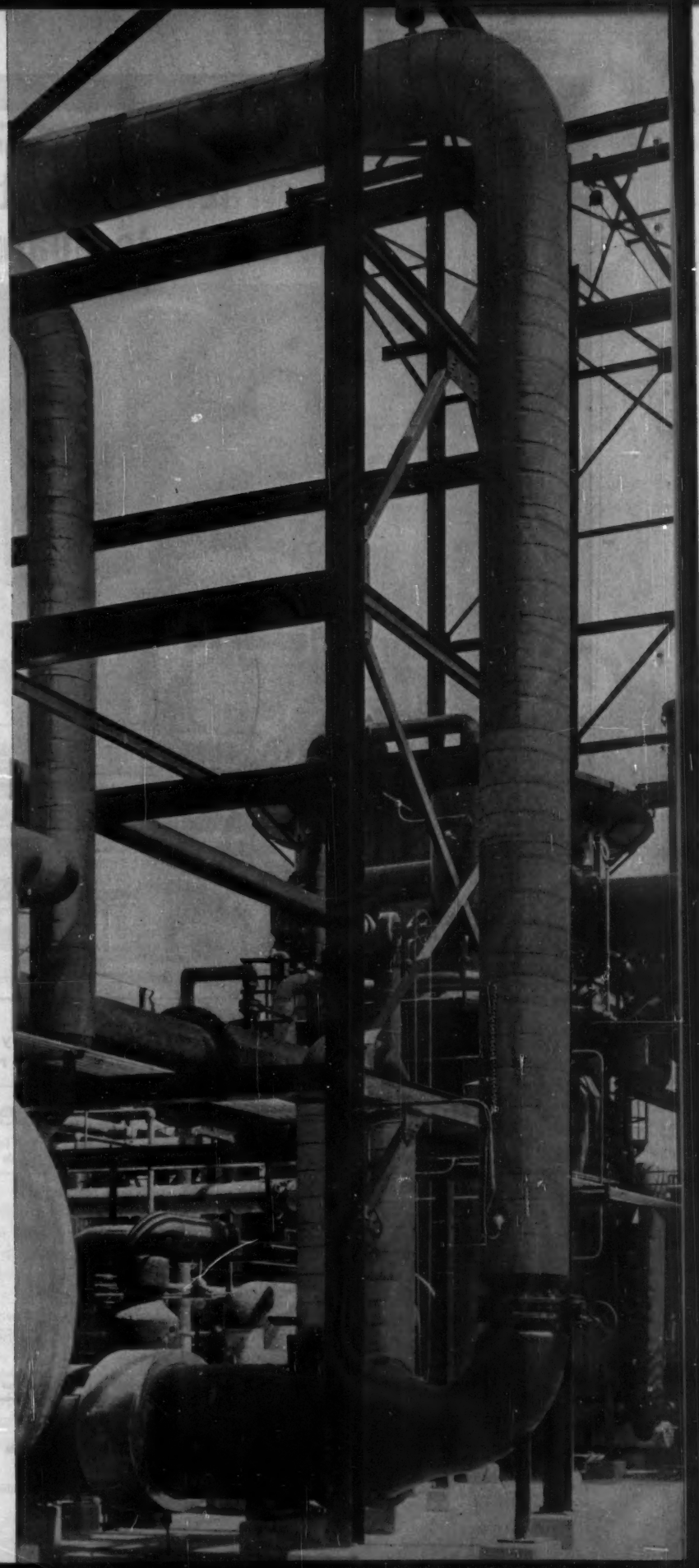
FOR A TEVA SURVEY, CALL YOUR LOCAL G-B INSULATION DISTRIBUTOR (LISTED IN THE ADJOINING COLUMN)

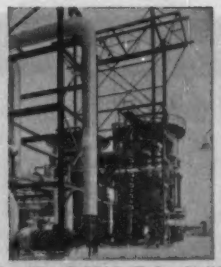
GUSTIN-BACON
Manufacturing Company

242 W. 10th St., Kansas City, Mo.

GUSTIN gb BACON

Thermal and acoustical glass fiber insulations • Pipe couplings and fittings • Molded glass fiber pipe insulation





G-B SNAP* ON DISTRIBUTORS

(See ad on facing page)

ALBUQUERQUE, Mt. States Insulation Co.
AMARILLO, Ball Distributing & Engr. Co.
ATLANTA, Ga., Reynolds Aluminum Supply Co.
BALTIMORE, Md., Leroy Insulation Co.
BILLINGS, Mont., Big Horn Supply, Inc.
BIRMINGHAM, Ala., Shook & Fletcher Supply
Reynolds Aluminum Supply Co.
BROOKLINE, Mass., Homans-Kohler, Inc.
BUFFALO, Industrial Insulation Sales, Inc.
CHARLESTON, W. Va., Baldwin Asbestos Products Co.
CHARLESTON HEIGHTS, S. C., Stafford Insulation Co.
CHARLOTTE, N. C., Guy M. Beaty & Co.
CHATTANOOGA, Guy M. Beaty & Co.
CHICAGO, E. C. Carlson Co.
CINCINNATI, R. E. Kramig & Co.
CLEVELAND, The Miles Materials Co.
COLUMBUS, Santeler Brothers
DALLAS, Insulation Supply Co., Inc.
DAVENPORT, Republic Electric Co.
DENVER, Gene Wright Lumber Co.
DES MOINES, Iowa Asbestos Co.
DETROIT, Coon DeVisser Co.
EL PASO, Insulation & Specialties Co.
FARGO, N. D., Smith, Inc.
FT. SMITH, Ark., Gunn Distributing Co.
FT. WAYNE, Ind., M. H. Hilt, Inc.
FT. WORTH, The Bracken Co.
GREENSBORO, N. C., Starr Davis Co., Inc.
GULFPORT, Miss, Paine Supply Co.
HOUSTON, Precision Insulation Co.
INDIANAPOLIS, Central Supply Co.
JACKSON, Miss., Paine Refrigeration & Supply Co.
JOPLIN, Mo., Joplin Cement Co.
KANSAS CITY, Kelley Asbestos Co.
LITTLE ROCK, Gunn Distributing Co.
LOS ANGELES, Western Fibrous Glass Products
Thorpe Insulation Co.
LOUISVILLE, General Insulation & Roofing Co.
MEMPHIS, John A. Denie's Sons Co.
MIAMI, Reynolds Aluminum Supply Co.
MILWAUKEE, F. R. Dengel Co.
MINNEAPOLIS, Asbestos Products, Inc.
MOBILE, Ala., Shook & Fletcher, Inc.
NASHVILLE, Reynolds Aluminum Supply Co.
NEWARK, N. J., Eastern Steam Specialty Co.
NEW HAVEN, Conn., Insulation Supply Co.
NEW ORLEANS, Eagle Asbestos & Packing
NEW YORK, Eastern Steam Specialty Co.
OKLAHOMA CITY, Ball Distributing & Engineering Co.
OMAHA, Cardinal Supply & Mfg. Co.
PHILADELPHIA, John F. Scanlan, Inc.
PITTSBURGH, Dravo Corp.
PHOENIX, Ariz., Kircher Asbestos & Rubber Co.
RALEIGH, N. C., Reynolds Aluminum Supply Co.
RAPID CITY, S. D., Robbins & Stearns Wholesale
RICHMOND, Va., Reynolds Aluminum Supply Co.
ROCKFORD, Ill, Mott Brothers Co.
SALT LAKE CITY, Bullough Asbestos Supply Co.
SAN ANTONIO, The Bracken Co.
SAN DIEGO, Western Fibrous Glass Products
SAN FRANCISCO, Western Fibrous Glass Products
SAVANNAH, Ga., Reynolds Aluminum Supply Co.
SEATTLE, Western Fibrous Glass Products
SOUTH BELOIT, Ill., Mott Brothers Co.
ST. LOUIS, The Stovey Company, Inc.
ST. PAUL, Asbestos Products, Inc.
SYRACUSE, N. Y., Industrial Supply Co.
TAMPA, Fla., Eagle Roofing & Art Metal Works, Inc.
TALLAHASSEE, Fla., Bakers, Inc.
TULSA, Okla., Ball Distributing & Engr. Co.
TUPELO, Miss., Paine Supply Co.
WASHINGTON, Walter E. Campbell Co., Inc.
WICHITA, Jamar-Olmen Construction
VANCOUVER, B. C., Fleck Brothers Limited

gb

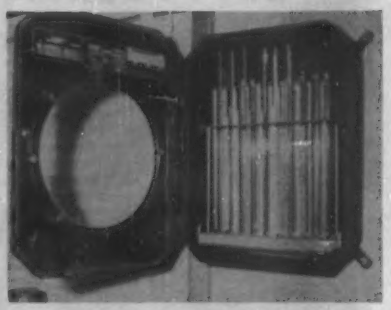
in operation for more than five years without a single failure.

Item submitted by:
Charles E. Wilson
Fractionator Operator
D-X Sunray Oil Co.
Duncan, Okla.

Meter Case Makes Good Rack For Thermometers

A meter case makes a safe, inexpensive, and convenient rack for laboratory thermometers as is shown in the pictures. The top of the rack is Masonite and the bottom is one-inch wood. The thermometers rest on a sheet of aluminum which covers the bottoms of the rack holes. The rack is supported by, and turns on an axle of one-quarter inch tubing attached to the case inner lugs. A lower projection of the aluminum sheet behind the rod support allows the rack to handle thermometers up to 15-inches long. A short arm extending from the rack top allows the rack to be pushed back as the door is closed.

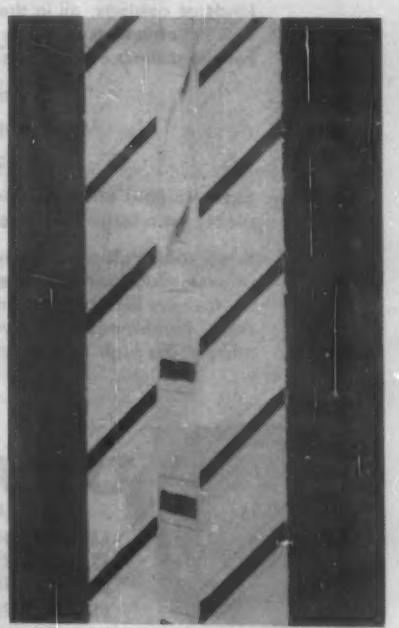
How to Do It . . .



Item Submitted by:
W. H. Ness
Signal Oil and Gas Co.
Tioga, North Dakota

Card Behind Gage Glass Spots Water Level Easily

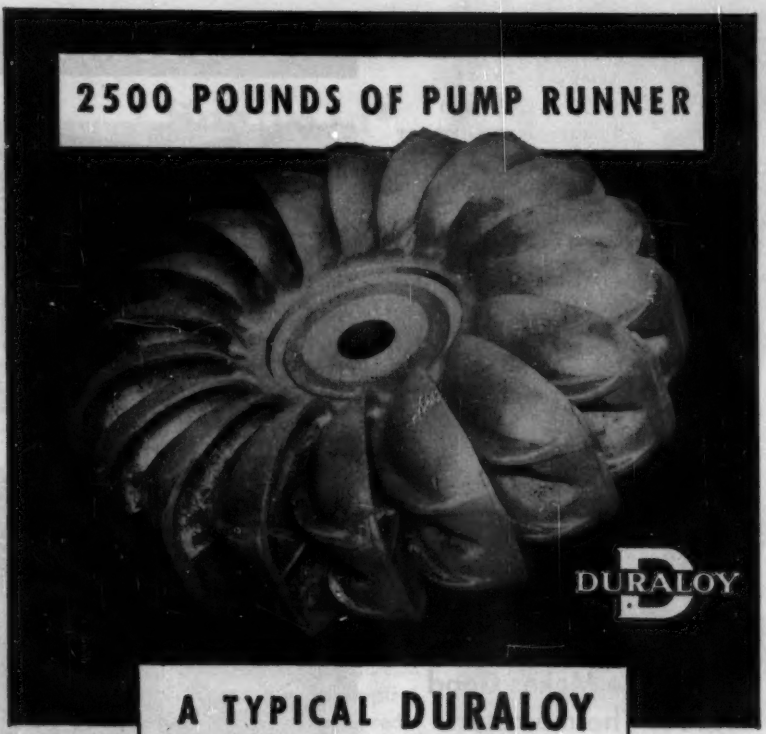
A reflex gage may be rigged up, on old style boilers, tanks, and separators which do not have modern reflex gauges, by inserting a striped card behind the gauge glass, as shown in the photograph.



Where the diagonal black strips cross the line of sight above the water level, the lines are turned to a steeper angle, but where the lines are below the water level, the lines are reversed in direction and the actual water line can easily be spotted at a point between the two lines.

The card is placed approximately one-half inch behind the gage glass and may be fastened with stove bolts. A covering of varnish may be applied to the card so that it can easily be

For more data on advertised products, use Readers' Service Cards, last page.



A TYPICAL DURALOY HIGH ALLOY CASTING

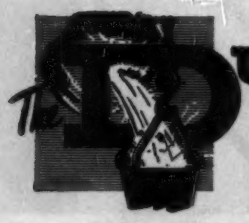
This casting is 18-8, destined for use under quite corrosive conditions. It's typical of the work done in our modern foundry for both manufacturers who need high alloy castings for their equipment and for plant operators who need castings to meet a corrosion problem, a high temperature problem or a combination of both, with or without abrasion as a contributing factor.

We here at Duraloy now offer several distinctly different kinds of castings, all in the corrosion-resisting, heat-resisting or abrasion-resisting class and each kind offering certain distinct advantages:

static sand castings
centrifugal castings
shell molded castings

Shell molding offers great economy in the casting of small pieces on a large mass production basis.

Bring your high alloy casting problem to Duraloy both for recommendations as to the best alloying combination and for foundry services in casting and finishing the piece. Our recommendations and service are backed up by more than thirty years high alloy casting experience.

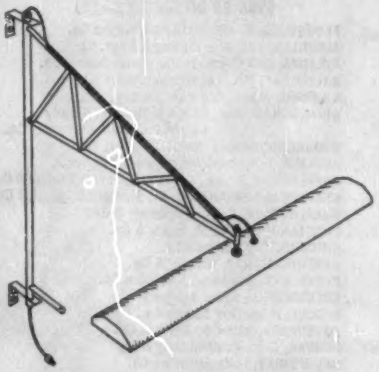


The DURALOY Company
OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
ATLANTA OFFICE: 76—4th Street, N.W.
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

How to Do It...

wiped off in case it becomes soiled from vapors. Where used on boilers, the cards are made of metal and the stripes made with heat resistant enamel.

Item submitted by:
Harry Hess
Wichita, Kansas



Put Light On Your Machine Work With A Boom Fixture

Working in a machine shop can be tedious, and the machinist needs all of the light that he can get. One problem with lighting a machine arises when a fixture is attached over it. It is then very difficult or impossible to bring large pieces of work to the machine by means of the overhead shop crane.

A solution to this problem is the fluorescent fixture boom that can be built and attached to a nearby wall or column. It swings conveniently out of the way when work is brought to the machine, and is again easily positioned for good lighting.

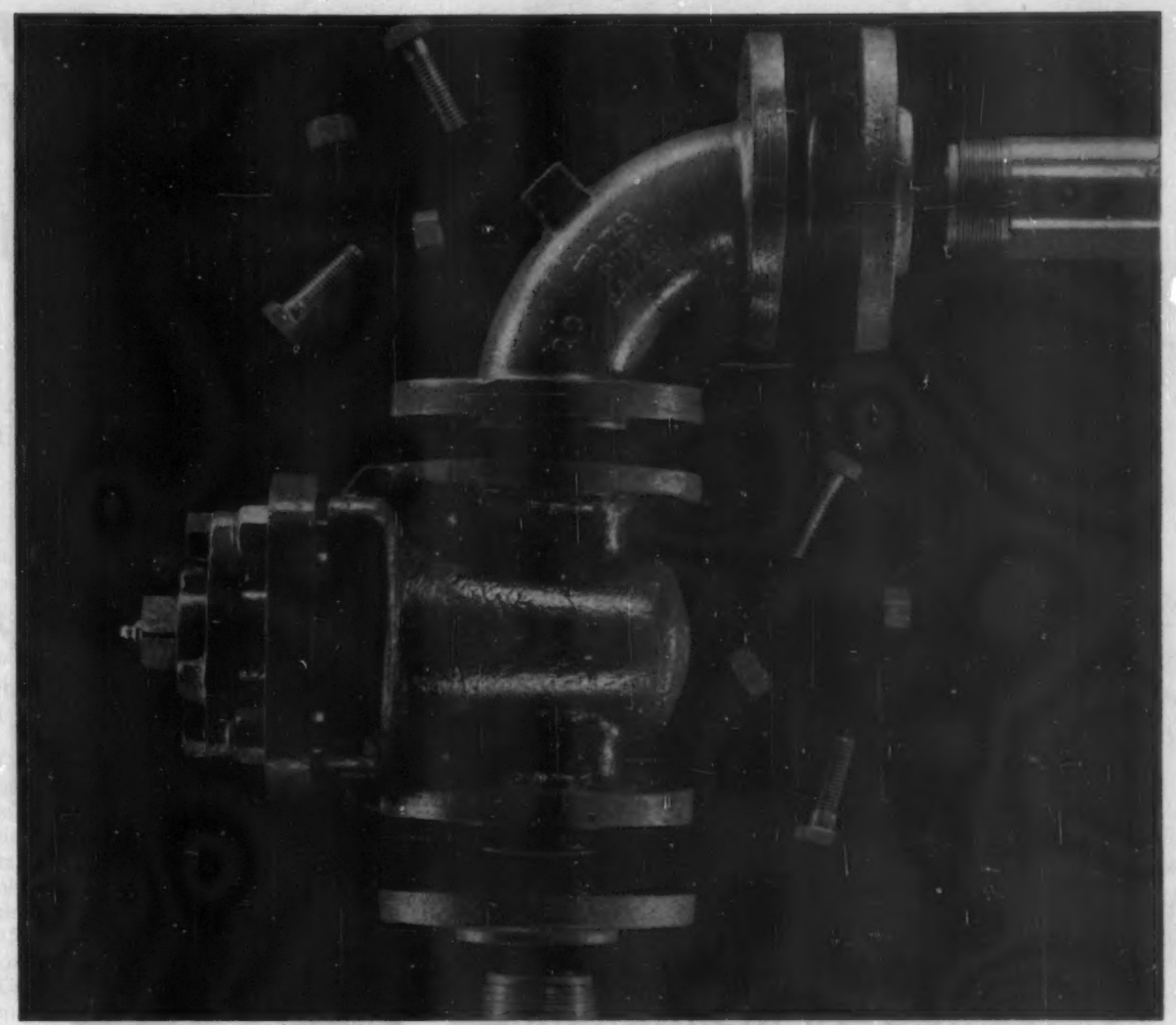
Try this idea and save your eyes.

Idea submitted by:
Jack O. Evans
E. I. du Pont de Nemours & Co., Inc.
Victoria, Texas

YOUR IDEAS ARE VALUABLE!

At least $10 will be paid for each idea accepted for "How to Do It." Just send a brief note with a photo or sketch to the Editor, *Petroleum Refiner*, P. O. Box 2608, Houston.

For more data on advertised products, use Readers' Service Cards, last page.



You can see why Saran lined pipe cuts operating costs

These corrosion-resistant pipes, fittings and valves are stock items, and they can be fabricated in the field

The long range economy of Saran lined pipe starts right here—with the immediate availability of pipe, fittings and valves . . . as stock items. There's no waiting . . . no price premium to pay.

And Saran lined pipe can be fabricated in the field. Only conventional hand tools or power equipment are needed to cut and thread it right on the job site.

Saran lined pipe pays off through the years with superior corrosion resistance and strength. When you specify the new gray Saran lined pipe, valves, pumps and fittings, you'll be able to pipe commonly used acids, alkalies and other corrosive liquids under a wider temperature range.

You can plan a *complete* corrosion-free pipe system with Saran lined pipe, valves, pumps and fittings. They're available for systems operating from full vacuum up to 300 psi and temperatures from –20° F to 200° F. Send the coupon today for further information. And be sure to ask about Saraloy® 898 tank lining, too. THE DOW CHEMICAL COMPANY, Midland, Michigan.

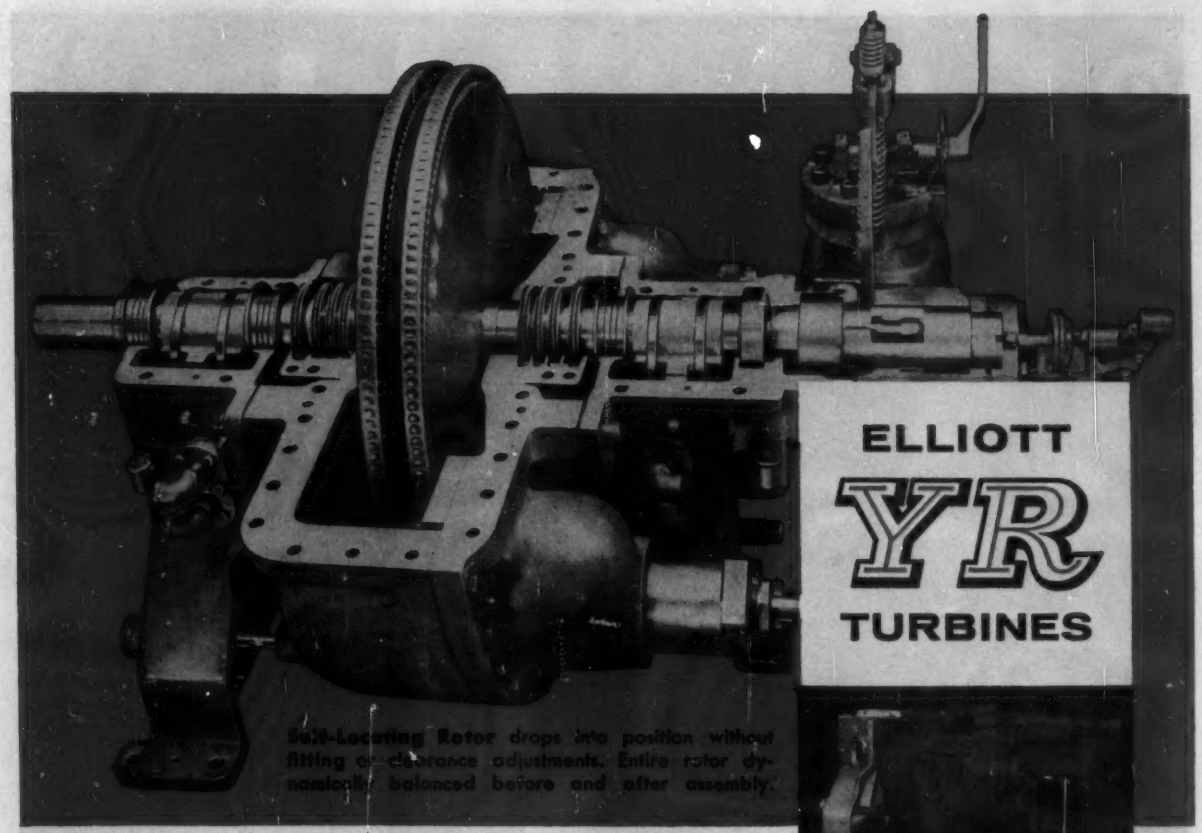
SARAN LINED PIPE COMPANY
DEPT. 2002F
2415 BURDETTE AVENUE
FERNDALE 20, MICHIGAN

Please send me information on: ☐ Saran lined pipe, fittings and valves ☐ Saran lined centrifugal pumps ☐ Saraloy 898 chemical resistant sheeting

Name_____ Title_____ Company_____

Address_____ City_____ State_____

YOU CAN DEPEND ON DOW



Self-Locating Rotor drops into position without fitting or clearance adjustments. Entire rotor dynamically balanced before and after assembly.

ELLIOTT

YR

TURBINES

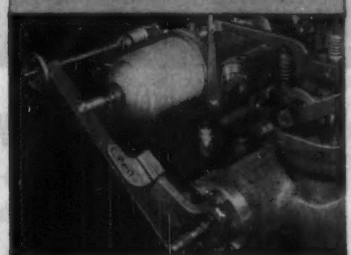
True Centerline Support assures accurate shaft alignment over entire range of operating temperatures, extends life of bearings of turbine and driven machines.

5 design features insure ...easy installation ...easy maintenance

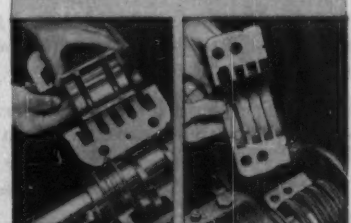
Dependability in long-term, continuous service is the principal reason why Elliott mechanical drive turbines have won such universal acceptance as prime movers for process and water pumps, fans, compressors and other driven machines.

But there's more to it than that. The popularity of Elliott YR single-stage turbines, in sizes from 2 to 600 hp, is also due to simplified design features which provide easy installation and easy access for routine inspection and maintenance. Five of these design features are illustrated here. The Elliott design also permits interchangeability of components from one turbine frame to another.

Other types of Elliott mechanical drive turbines are available, in sizes up to 20,000 hp. And when it comes to application engineering or maintenance assistance, your local Elliott field engineer is always available. For complete details write Elliott Company, Steam Turbine Department, Jeannette, Pa. Ask for Bulletin H-22B.



Weather-Proofed, Reliable Speed-Governing System maintains effective steam seal for long operating periods. Separate overspeed trip gives positive overspeed protection.



Liner Type Bearings (left) are sealed against elements, permit rapid heat transfer to cooling oil, are easy to inspect or replace.

Accessible Shaft Seal Covers (right) are easy to remove for inspection or ring replacement.

ELLIOTT Company

TURBINES FOR DEPENDABLE day-in/day-out SERVICE

For more data on advertised products, use Readers' Service Cards, last page.

Who's Building . . .

New Polyethylene Plant for Bakelite

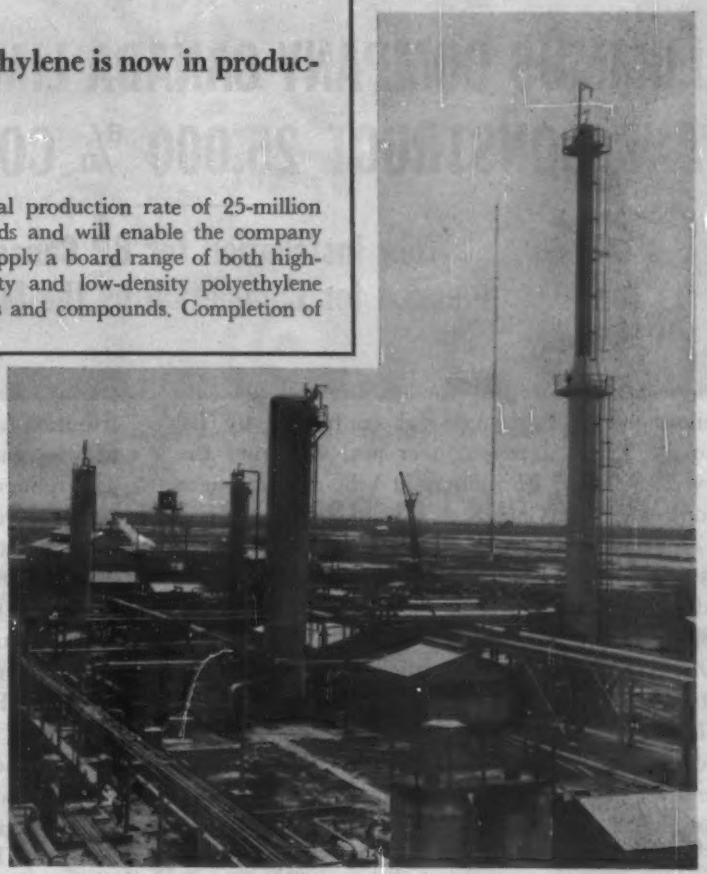
High-density polyethylene is now in production at new West Virginia plant.

A new fully automated plant for making high-density (low pressure) polyethylene is now in commercial production. Located at Institute, West Virginia, the plant's production is based on Ziegler-type catalysis, producing at an annual rate of 30-million pounds.

R. K. Turner, president of Bakelite Co., division of Union Carbide Corp., said "These latest high-density polyethylene materials possess a combination of properties which will create many new plastics markets. They will also command a share of present plastics markets, including possibly 10 to 15 percent of the present market for conventional low-density polyethylene. Certain housewares made from these materials will benefit from the properties of rigidity, impact resistance, high gloss and colorability imparted by high-density polyethylene. In the wire and cable field, the new materials will make possible superior abrasion resistance and thin-wall electrical insulation. Superior purity and resin uniformity of the materials are ensured by special control equipment."

The new high-density resins are adaptable to film extrusion, extrusion coatings over paper, sheet extrusion, contour extrusion, extrusion over wire and cable, monofilament extrusion, vacuum forming, blow molding, injection molding and calendering.

Another high-density polyethylene plant, located in Seadrift, Texas, will produce Phillips-type resins and will be placed in commercial production shortly. Upon the completion of this plant, high-density polyethylene annual capacity will be 55-million pounds. These facilities will have an annual production rate of 25-million pounds and will enable the company to supply a board range of both high-density and low-density polyethylene resins and compounds. Completion of



New expansion includes 125-foot de-ethanizer tower.

Shell Expands Natural Gasoline Plant

A major expansion designed to double their output of natural gasoline in the Iowa, La., field has been completed by Shell Oil Co. This is the third expansion undertaken by Shell at their gasoline plant in the Southwest Louisiana location in six years. Daily production from the new installations is expected to top 40,000 gallons of natural gasoline from 55 million cubic feet of natural gas. Previously, production averages ran 23,000 gallons per day from the same amount of gas.

The largest single piece of equipment installed in the Iowa project is a rich oil de-ethanizer, a huge vessel 125 feet tall and weighing 45 tons. It was transported to Iowa on three rail flat cars from the Union Tank Co. plant in Houston, where it was fabricated.

Other equipment installed included direct fired oil heaters to serve the de-ethanizer, rich and lean oil pumps, electric motors, heat exchangers, transformers and three 55,000 gallon storage tanks.

The expansion project was contracted by Farnsworth and Chambers, Inc., Houston, and work was begun in the fall of 1957.

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

385 Madison Avenue New York 17, N. Y.

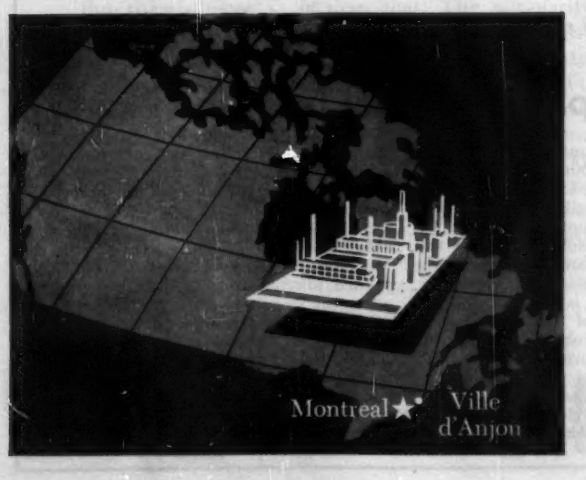
LUMMUS COMPANY CANADA LIMITED TO ENGINEER AND CONSTRUCT 25,000 B/D COMPLETE REFINERY

New Installation for BP Canada Limited Planned for Completion by the Middle of 1960

The Lummus Company Canada Limited has been announced as the successful contractor by BP Canada Limited to engineer and construct the new 25,000 B/D BP refinery at Ville d'Anjou, near Montreal, P. Q., Canada.

The basic process units will consist of a crude distillation unit with a total charge of 25,000 BSD, a distillate treatment unit with a charge of 12,000 BSD, a catalytic reforming unit with a charge of 6,000 BSD, and a catalytic cracking and polymerization unit with a fresh feed charge of 9,000 BSD.

In addition, the refinery will contain a wharf and transit site for the receipt of feedstocks and the dispatching of products by tankers, and a pipe route connecting the refinery to the wharf and transit site. There also will be road and rail distribution facilities for products, necessary tankage, utilities and buildings, and fire fighting facilities. The refinery will be laid out in such a way as to permit future expansion double that of the original capacity.



The refinery is being designed by The Lummus Company Canada Limited to produce primarily 400,000 tons per year of gasoline, and, in addition, aviation turbine fuel, stove oil, diesel oil, and other products. Preliminary work on the site and on a three mile pipeline to the St. Lawrence River is already under way.

BP Canada Limited, with its executive office in Montreal, is the subsidiary of British Petroleum Company Limited, conducting marketing operations in Canada. It is understood that another BP company is being formed to own and operate the refinery.

The refinery at Ville d'Anjou will be the twentieth complete refinery engineered by Lummus throughout the world since the end of World War II. For design, engineering and construction of refineries anywhere in the world—Lummus' over fifty years of world-wide experience on over 700 plants for the process industries is at your disposal.

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, N.Y., Houston, Chicago, Washington, D.C., Montreal, London, Paris, The Hague, Caracas, Maracaibo. *Engineering Development Center*, Newark, New Jersey.

the project is expected in the first half of 1958.

As in the case of Union Carbide's other polyethylene plants, the new plants were built by Union Carbide Chemicals Co. Bakelite Company will direct operations, sales and technical services. Both companies are divisions of Union Carbide Corp.

Five other plants are currently involved in the production and compounding of Bakelite polyethylene resins. These are located at Bound Brook, N. J.; South Charleston, W. Va., Texas City, Texas; Torrance, Calif.; and Ottawa, Ill.

Continental Oil Co. is installing an electronic computor-data processing system at its Ponca City, Okla., refinery. The installation, to be handled by Beckman Instruments, Inc., will be used with a 10,000-bpd catalytic reformer, producing high-octane gasoline. Production yields and other operating statistics will be computed automatically, with a warning given if any of the operating variables begin to drift.

Japan has received permission to build a 5,000-bpd refinery near Bangkok, Thailand. The plant, which will be financed by a loan from Japan's export-import bank, will be constructed and engineered by several Japanese firms. The Thai government has given no response to another Japanese plan for a 15,000-bpd plant proposed by Nippon Steel Tube Co.

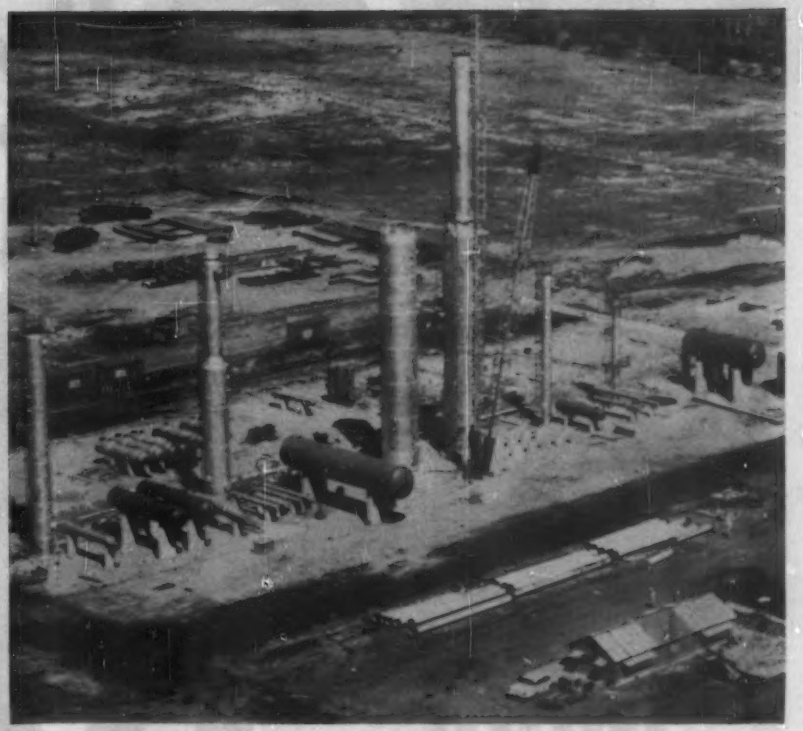
Sohio Oil Co.'s Toledo refinery has placed a $3.4 million alkylation unit on stream. This new unit will have a daily capacity of 150,000 gallons of high octane gasoline components. It is an advanced version of the alkylation plant constructed at the Toledo refinery in 1953, which is used to produce components for aviation gasoline. The feed stock for the new Cleveland unit is butane gases from the catalytic cracking operation. A sulphuric acid catalyst is used in the new alkylation unit.

British Petroleum Canada, Ltd., has awarded a contract to The Lummus Co. Canada, Ltd., to engineer and construct a 25,000-bpd refinery at Ville d'Anjou near Montreal, P.Q., Canada.

The basic process units will consist of a 25,000-bpsd crude distillation unit, a 12,000-bpsd distillate treatment unit, a 6,000-bpsd catalytic reforming unit, and catalytic cracking and polymerization unit with a fresh feed charge of 9,000 bpsd.

The refinery will be constructed to permit future expansion double that of the original capacity. It will produce gasoline, aviation turbine fuel, stove oil, diesel oil, and other products.

Preliminary work on the site, and on a three mile pipeline to the St. Lawrence River, is already under way. Completion of construction for the refinery is planned for mid 1960.



This new plant will produce 17,130 bpd of liquefied gas.

Creole Plant Is Largest in Latin America

Production has begun at Creole Petroleum Corporation's new liquefied gas plant at the company's Ule' refinery in Venezuela. An initial run has confirmed that the plant will produce 17,130 bpd under favorable conditions, (5,300 barrels of propane, 5,760 barrels of butane, and 6,070 barrels of natural gas). The new plant is the largest in Latin America and one of the three largest in the world.

The gas used at the new plant is compressed at the company's Tia Juana #1 gas conservation plant on Lake Maracaibo. From there part of it is returned to underground reservoirs to increase the total recovery of oil by natural flow.

D-X Sunray Oil Co. has closed out the last of its blending operations at its now-obsolete refinery at Allen, Okla. Remaining facilities at the Allen plant, which has operated for nearly 40 years, will remain standing for the time being.

Canadian Industries, Ltd., has completed a new anhydrous ammonia plant at Millhaven, Ontario. The $9-million plant has a capacity of 200-tons-per-day of anhydrous ammonia. It is located near the company's Lake Ontario Dacron plant.

The Texas Co. and several other oil companies will build a natural gasoline plant in Beaver County, Okla., with Texaco to be the operator. The plant is expected to cost about $1.5-million.

Sun Oil Co. has announced plans for construction of a $4 million gasoline plant at Laverne, Okla.

Salt Lake Refining Co. has placed a new UOP Platformer on stream at its Salt Lake City refinery. Processing straight run naphtha in the 200F and 400F boiling range, the catalytic reformer has an output of 8,000 bpd.

Imperial Chemical Industries, Ltd., is building a plant at Billingham, England to expand production of alkylated phenols. The company forecasts a considerable increase in the United Kingdoms export drive because of the new plant.

Pan American Petroleum Corp. and **La Gloria Oil & Gas Corp.** are building a natural gasoline plant just south of Marshall, Texas, with completion slated for late 1958.

Petroleo Brazileiro S.A. (Petrobras) has signed a contract with Foster Wheeler Corp. for the new Duque de

40% 40% 40%

MORE WATER

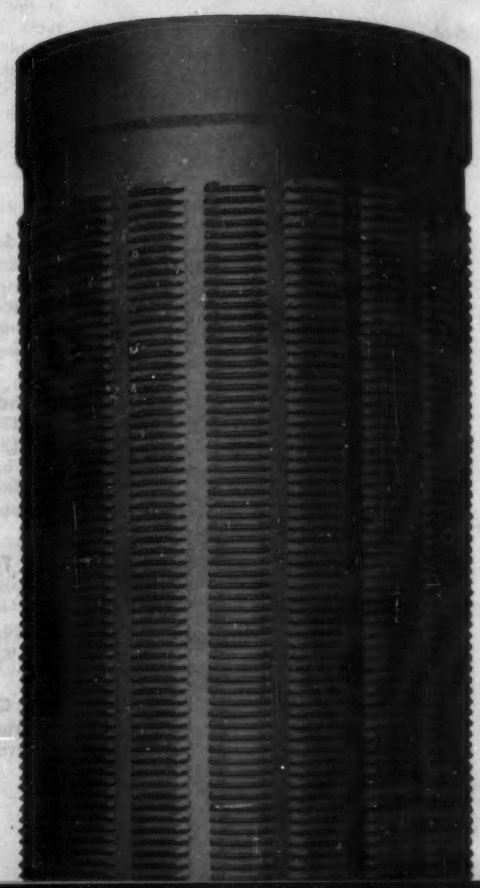
can flow through the NEW Layne 134 shutter screen

WHY? *Increased inlet area!*

Here's a screen that is even more efficient . . . has *greater strength* than the long-lasting Layne 96 shutter screen that made Layne water wells famous.

This new development of Layne creative research is used only in Layne water well installations, and available exclusively through Layne Associate Companies.

Contact your nearest Layne Associate Company for complete details.



LAYNE & BOWLER, INC. MEMPHIS
General Offices and Factory
Memphis 8, Tenn.

Layne Associate Companies throughout the world.

WATER WELLS

VERTICAL TURBINE PUMPS • WATER TREATMENT

Layne

ASSOCIATE COMPANIES

LAYNE ARKANSAS COMPANY
Stuttgart, Arkansas

LAYNE-ATLANTIC COMPANY
Norfolk, Virginia
Glen Burnie, Maryland
Savannah, Georgia
Orlando, Florida
Albany, Georgia
Florence, South Carolina

LAYNE-CENTRAL COMPANY
Memphis, Tennessee
Jackson, Mississippi
Cleveland, Mississippi
Pensacola, Florida

INTERNATIONAL WATER CORPORATION
Pittsburgh, Pennsylvania

LAYNE-LOUISIANA COMPANY
Lake Charles, Louisiana

LOUISIANA WELL COMPANY
Monroe, Louisiana

LAYNE-MINNESOTA COMPANY
Minneapolis, Minnesota

LAYNE-NEW YORK COMPANY
Linden, New Jersey
New Hyde Park, L.I., New York
Camden, New Jersey
Arlington, Massachusetts
Pittsburgh, Pennsylvania

LAYNE-NORTHERN COMPANY
Mishawaka, Indiana
Indianapolis, Indiana
Lansing, Michigan

LAYNE-NORTHWEST COMPANY
Milwaukee, Wisconsin

THE LAYNE OHIO COMPANY
Columbus, Ohio
Akron, Ohio
Lima, Ohio
Springfield, Ohio

LAYNE-PACIFIC, INC.
Seattle, Washington

LAYNE TEXAS COMPANY
Houston, Texas
Dallas, Texas
Corpus Christi, Texas
El Paso, Texas

LAYNE-WESTERN COMPANY
Kansas City, Missouri
St. Louis, Missouri
Aurora, Illinois
Ames, Iowa
Omaha, Nebraska
Wichita, Kansas
Denver, Colorado

CANADA

INTERNATIONAL WATER SUPPLY, LTD.
London, Ontario, Canada
Oakville, Ontario, Canada
Montreal, Quebec, Canada
Quebec, Quebec, Canada
Saskatoon, Saskatchewan, Canada
Vancouver, B.C., Canada

Caxias refinery near Rio de Janeiro, Brazil. The contract, which is expected to exceed $40 million, will comprise a complete 90,000-bpd refinery including crude distillation, catalytic cracking, catalytic reforming, propane decarbonization and treating processes, steam and power generating equipment, tankage and other off-site facilities. Completion of the project will require over two years. It involves one of the largest single industrial contracts ever awarded in Brazil.

Who's Building. . .

Floor space at new plant is equal to 100 average-sized homes

Magnolia Up With Lube Plant at Beaumont

Completion or near-completion of a half-dozen major refinery operating units, including a vast, highly mechanized new blending and packaging plant at Beaumont was disclosed recently by Magnolia Petroleum Co.

One of the projects just completed is a completely functional ranch-style plant for blending and packaging some 120 different lube oil products. The plant's floor space—148,000 square feet—is roughly equivalent to that of 100 average-sized homes.

A one-story structure, the plant houses, among other things, an ultra-modern device which blends up to 500 gallons of oil per minute, simultaneously controlling the mixture of three mineral oil components and six additives. New equipment includes a one-quart canning line for motor oils which fills, seals and packages up to 500 cans per minute, or more than eight cans per second.

Other new projects recently completed or presently under construction include:

1. A new alkylation unit for producing high-octane components for motor and aviation fuels. Scheduled for startup this month, the unit will combine propylenes and butylenes and isobutane to produce alkylate—about 8,000 bpd.

2. A 30,000-bpd Sovafiner unit. Already past the half-way point, the unit is due to be completed about September, 1958.

3. A new plant for recovery of hydrogen sulfide from liquid and gas feed stocks going to new alkylation unit. The process has entered startup operations.

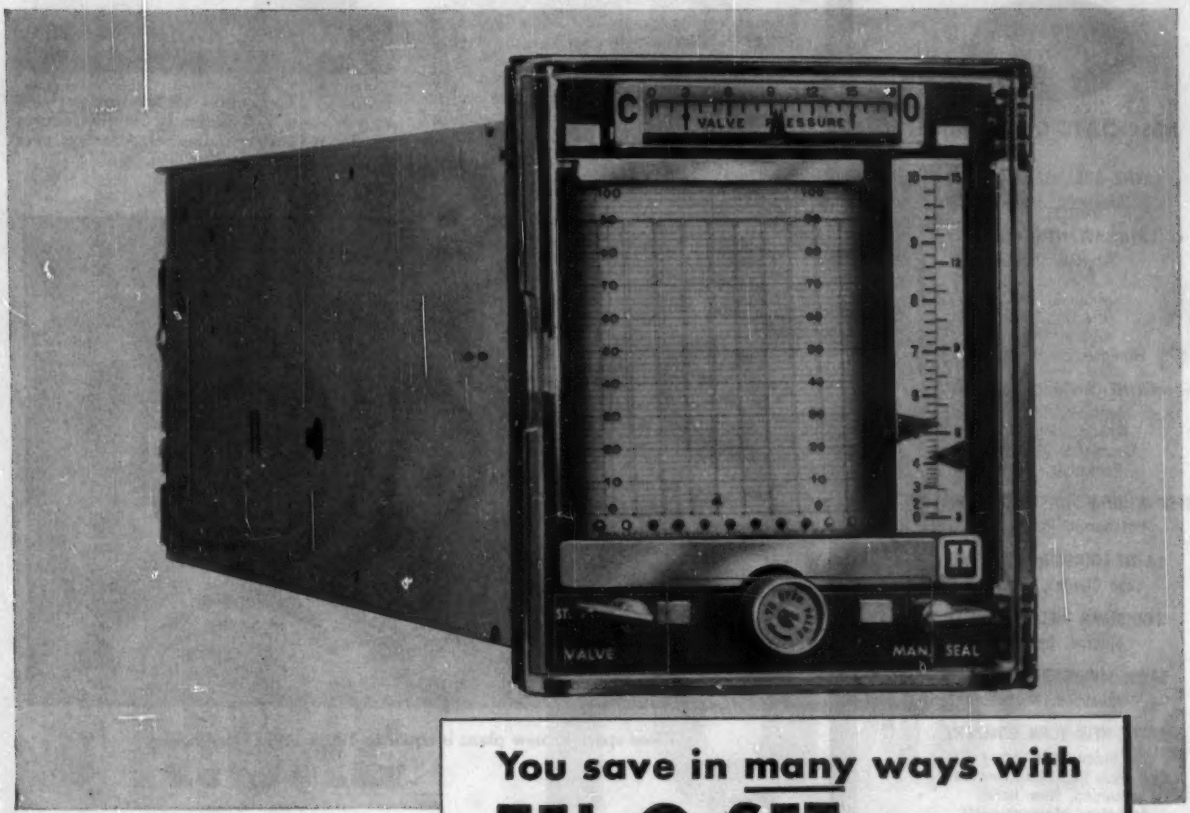
4. Expansion of a LPG fractionation system, including installation of a new 194-foot, 200-ton de-isobutanizer tower. To be completed this month, the new facilities give the refinery a 20 percent boost in LPG processing capacity—an increase of 6,500 bpd.

5. A giant 100,000-bpd crude oil-distillation unit. To occupy an area almost as large as a city block, the process will distill crude oil into unfinished butanes, gasolines, naphtha, kerosine, gas oils, lubricants and residuum. The unit is now more than half complete and is due to be finished about September, 1958. It will eventually replace seven smaller crude units.

Foster Wheeler Corp. of New York is contractor for the Sovafiner hydrogen sulfide recovery system and the new crude distillation unit. Contractor for the LPG expansion is Fluor Corp. of Los Angeles, and for the alkylation unit, C. F. Braun and Co. of Alhambra, Calif. Magnolia served as its own general contractor for the blending and packaging plant.

Wyandotte Chemical Corp. has completed an oxide products plant at Wyandotte, Mich. The unit more than doubles the company's production of ethylene oxide and propylene oxide derivatives.

India will be provided with $18.9-million from Rumania in the form of equipment and technical assistance for one of its two planned refineries. An agreement on Rumanian aid in building the proposed



You save in many ways with TEL-O-SET receivers...

today's most advanced miniature pneumatic instruments

Record or indicate any process variables with versatile *Tel-O-Set* receivers. They're the most dependable, economical, and easily-serviced miniature instruments you can buy.

CUT INSTALLATION COSTS

- Startup is safeguarded by wiring and piping case separately . . . keep chassis safe in original carton until startup.
- Quick-connect design makes chassis mounting easy, fast, foolproof.

CUT SPARE PARTS INVENTORY

- Use any *Tel-O-Set* receiver with any pneumatic force-balance controller.
- Change recorder to indicator and vice versa . . . without changing case or disturbing field connections.

REDUCE PROCESS DOWNTIME

- All working parts can be inspected during operation, without process interruption.
- Zero and span, the only adjustments required, are set from front of panel.

SAVE IN MAINTENANCE

- Separate pneumatic and electric connections—no need for electrician to stand by.
- Linearity built in at factory, requires no attention.

Get complete details on receivers and other *Tel-O-Set* instruments from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Aves., Phila. 44, Pa.

Honeywell

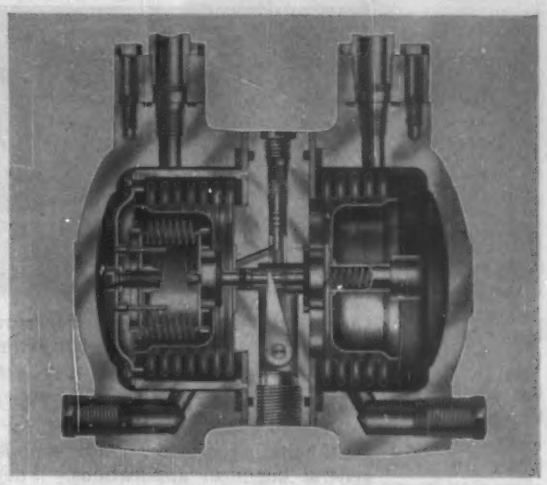
H HONEYWELL *First in Controls*

NEW!

Honeywell Bellows Meter...

unequalled for accuracy, stability, versatility in flow and liquid level metering

The new Honeywell Bellows Flow Meter gives the better performance demanded by its potential users. It's the most advanced meter body available today, with important advantages never before found in flow and liquid level meters.



Some of its outstanding features:

Sensitive and accurate—Sensitive to within 0.05% of full scale ... calibrated accuracy ±0.5% of full scale.

Leakproof—Between liquid fill and process fluid.

Automatically stabilized—Changes in meter body temperature or static pressure have no effect on output shaft position. The Honeywell Bellows Meter operates efficiently in surrounding temperatures of minus 40°F to plus 250°F.

Unmatched convenience features—Including fast range changing in the field ... connections for both horizontal and vertical piping ... quick calibration and adjustment ... easy cleaning and servicing.

High corrosion resistance—Seamless, stainless steel formed bellows give long, trouble-free service with virtually all process fluids.

Fast, effective damping adjustment—New type pulsation check with rectangular orifice enables essentially linear damping adjustment ... and you can adjust from outside the meter body during operation.

Models are available in many ranges, for both flow and liquid level measurement and control. Get details on *all* the features of the new Honeywell Bellows Meter by calling your nearby Honeywell field engineer today ... he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

REFERENCE DATA: Catalog C22-1

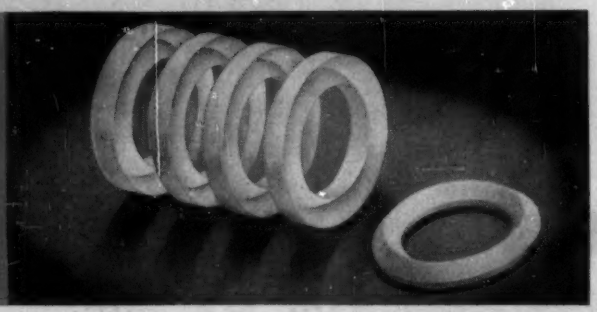
Honeywell

First in Controls

CHEAPEST PACKINGS
in corrosive service

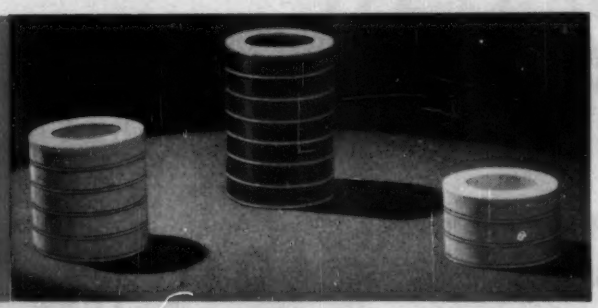
cost less per month of life
cost less in shutdown time
cost less in maintenance labor

VALVES



Chemiseal† Valve Packings, made of du Pont TEFLON, are available in V-type, diagonal, triangular, conical and Garlock Chevron* ring designs. They last months and years in chemical services where other packing materials fail in hours. They seal at low gland pressure and reduce torque required to operate the valve.

PUMPS



Chemiseal Pump Packings offer remarkably trouble-free service and useful life many times that of other type packings.

Molded from pure shredded TEFLON with TEFLON suspensoid, Garlock No. 9167, for positively non-contaminating service. (Also supplied graphited for general chemical applications.) They provide a low friction 2-way seal not only preventing axial seepage but seal against both shaft and stuffing box as well.

†U.S.G. trademark
*Garlock trademark

For prompt service, contact one of The Garlock Packing Company's 30 sales offices and warehouses throughout the U.S. and Canada, or write

United States Gasket Company
Camden 1, New Jersey

United States Gasket *Plastics Division of* **GARLOCK**

Who's Building . . .

20,000-bpd plant was reached recently in New Delhi. Total cost of the refinery would be $31.5 million.

The Soviet Union has offered aid in setting up a 30,000-bpd plant at Bihar, but no specific agreement has been reached.

The Texas Co. has added an 80,000-bpd vacuum pipe still to its Port Arthur, Texas, refinery. The unit will replace old facilities having a 60,000-bpd capacity, giving the refinery a rated crude capacity of 250,000 bpd.

Richmond Exploration Co. is prepared to receive bids for an 8-inch gas line to supply its 20,000-bpd plant at Bajo Grande, Venezuela. The refinery is on the western shore of Lake Maracaibo. The company planned to use gas from its own Ensenada field, but the supply was too small.

Imperial Oil Co., Ltd., will build a 1,500-bpd asphalt plant at its Edmonton, Alberta, refinery. Contracts for the $1.4-million plant will be awarded this summer, with completion expected by next spring. A continuous oxidizer and seven 10,000-barrel storage tanks are among the installations.

Copolymer Corp., Baton Rouge, La., is now building a $3-million plant to expand production facilities for its new dry rubber. Full scale production will begin in November, and steam generating facilities will be ready September. The company is also working on a $500,000 research lab.

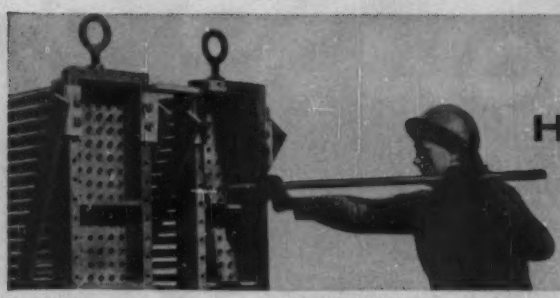
Utah Oil Refining Co. will go on stream with its 37,500-bpd asphalt plant this month. The $2-million crude oil unit will have seven product streams, running from reduced crude and diesel oil to light naphtha. The Fluor Corp. will do the designing and building.

Socony Mobil Oil Co. will raise capacity of its 28,500-bpd crude distillation unit by 20 percent. It's slated to go on stream at the end of the year.

Koppers Co. is planning to double the capacity of its Port Arthur, Texas, polyethylene plant. The expansion plans follow closely a recent project which increased the plants' output 20 percent.

American Independent Oil Co. is planning to build a refinery at Kuwait, Saudi Arabia (neutral zone). The plant will be a 40,000-bpd crude stabilization unit. It will not have a complete range of processing units, nor a full line of products. Caroll Bradberry & Associates, Los Altos, Calif., will design the project, while Arabian Bechtel, Ltd., will handle construction.

Societe Nationale des Petroles d'Aquitaine and **Firestone Rubber Co.** plan to build a 40,000-ton-per-year styrene-butadiene rubber plant in France. The French company will furnish 85,000 tons of butane per year to operate the plant, while Firestone will provide financial aid and equipment.

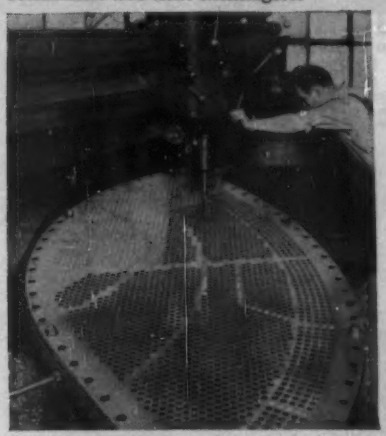


CONDENSER AND HEAT EXCHANGER CLINIC

Edited by Arthur W. Tracy, Metallurgical Engineer
The American Brass Company, Waterbury, Conn.

Selecting alloys for rolled tube sheets and baffles

Tube sheets and baffles are available from The American Brass Company in a wide variety of shapes, sizes and alloys to meet the problems of corrosion, pressure, and temperature encountered in condensers and heat exchangers.



Reaming a large condenser tube sheet of Naval Brass-450.

The following Anaconda alloys are those most widely used for tube sheets and baffle plates.

Leaded Muntz Metal-274 has good strength, stiffness and elasticity. It machines well and is the most commonly used tube-sheet metal. Leaded Muntz Metal hot rolls easily and can be manufactured in very large sizes. Many of the other tube-sheet alloys are superior to Leaded Muntz Metal in corrosion resistance and are used in preference to it for that reason. However, tube sheets are necessarily so thick that a long time elapses before they are affected by corrosion to the extent that their strength or usefulness is impaired.

Naval Brass-450 is an alloy of the same general type as Leaded Muntz Metal but includes approximately 0.75% tin in its composition. The tin content increases the alloy's resistance to corrosion, and makes it preferable to Leaded Muntz Metal, especially at higher-than-normal working temperatures. Hot-working properties of Naval Brass are similar to those of Leaded Muntz Metal.

Arsenical Admiralty-439 is resistant to dezincification corrosion and can be used where its higher resistance to corrosion is required, especially in process equipment.

Ambraloy-917 is available for use where strength and corrosion resistance superior to Naval Brass and Admiralty Metal are desired, as in oil-cooler tube sheets.

Cupro Nickel, 10%-755 and Cupro Nickel, 30%-702 are used extensively with tubes of similar composition in marine condensers and process heat exchangers.

Baffle and Support Plates for use in oil-refinery equipment are most often of Leaded Muntz Metal and Yellow Brass. For more severe applications, Admiralty, Naval Brass, Cupro Nickel, Copper and Everdur® are often employed.

Rolled Plates Superior. Anaconda sheets, plates, and circles are produced by the rolling process. They are commercially flat, accurate in dimensions, and free from the surface imperfections and porosity often prevalent in cast plates.

Standard Sizes. The American Brass Company makes plates for condenser tube sheets of copper and a number of copper alloys in rectangular sizes up to 156 inches in width and weights up to 15,000 pounds for any shape that can be cut from such sheet. The maximum standard limits for circles are 160 inches in diameter and 11,000 pounds in weight. Half circles can be produced up to 13,000 pounds in weight.

Rolled circles of Ambraloy-917, 2" thick, for water-to-water heat exchanger tube sheets requiring superior strength and corrosion resistance. Such circles can be furnished up to 5" thick, offer savings in material cost over comparable circles produced by the forging process.

Special jobs. When specifications call for extremely large plates or special alloys for special applications, The American Brass Company will gladly cooperate in the solution of such problems. For further information on Anaconda Condenser Tubes or Tube Sheets write: The American Brass Company, Waterbury 20, Conn. 5875

Nominal compositions of Anaconda condenser tube sheet and plate stock

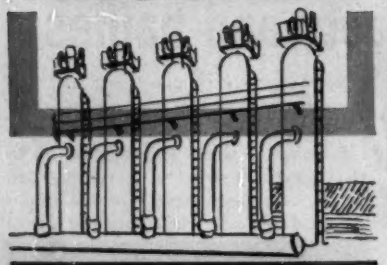
Alloy	Copper %	Zinc %	Tin %	Nickel %	Aluminum %	Lead %	Manganese %	Phosphorus %	Silicon %	Iron %	Arsenic %
Leaded Muntz Metal-274	60.0	39.40	—	—	—	0.60	—	—	—	—	—
Naval Brass-450	60.0	39.25	0.75	—	—	—	—	—	—	—	—
Arsenical Admiralty-439	71.0	27.96	1.0	—	—	—	—	—	—	—	0.04
Ambraloy-917 (Aluminum Bronze)	82.0	—	—	5.0	9.50	—	1.0	—	—	2.50	—
Cupro Nickel, 30%-702	68.9	—	—	30.0	—	—	0.60	—	—	0.50	—
Cupro Nickel, 10%-755	88.35	—	—	10.0	—	—	0.40	—	—	1.25	—
Phosphorized Copper-103	99.90+	—	—	—	—	—	—	0.02	—	—	—
Everdur*-1010	95.80	—	—	—	—	—	1.10	—	3.10	—	—

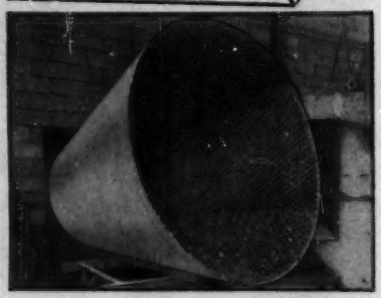
*T.M. Reg. U. S. Pat. Off.

ANACONDA®
Tubes and Plates for Condensers and Heat Exchangers
Made by
The American Brass Company

For more data on advertised products, use Readers' Service Cards, last page.

FEWER "TURN-AROUNDS"





Shutdowns for repairs of fire clay linings in refractory units are expensive. The frequency and duration of these shutdowns can be greatly reduced by the use of a steel grating armor known as "Gridsteel", which holds the castable refractory linings in place longer and armors them against the bombardment of catalytic elements.

"Gridsteel" is available in a special loose clinch to conform easily to curved surfaces.

For complete information, write for brochure on Irving "Gridsteel" Contour Retainer Mesh

★

"A Fitting Grating for Every Purpose"

IRVICO

IRVING SUBWAY GRATING CO., Inc.
Originators of the Grating Industry

Offices and Plants at
5090 27th St., LONG ISLAND CITY 1, N. Y.
1890 10th St., OAKLAND 23, CALIFORNIA

Who's Building...

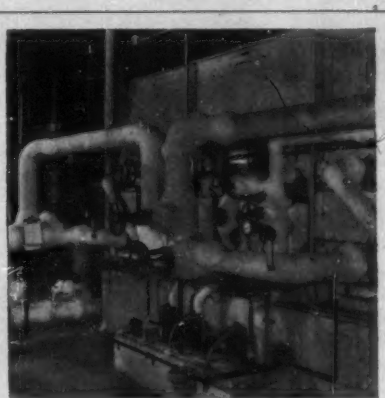
New 20,000-bpd refinery to be on stream in November.

Port Moody Construction on Schedule

British American Oil Co.'s new Port Moody refinery is taking shape as shown by this recent aerial photo of the construction site near Vancouver, British Columbia. It is presently estimated that the 20,000 bpd refinery will be on stream in November. Work on the process units, tank farm and other offsites has been kept on schedule despite the heavy rainfall encountered during the winter according to Canadian Kellogg, Toronto, builder of the refinery.

Burrard Inlet can be seen at the top of this view looking northwest, and also the

...a machine with "A GOOD RECORD as a REVENUE PRODUCER"



A typical case of using a Niagara Aero Heat Exchanger to provide cooling for production equipment shows amortization of this machine in 16 months and $90 per day revenue thereafter.

Industrial engineers with careful cost, upkeep and revenue records on all machines, credit Niagara Aero Heat Exchangers with important gains over other methods.

They use these machines to provide cooling for production equipment, welders, extruders, drawing dies, furnaces, quench baths, plating, chemical and electronic process...all millwater system uses.

They get positive control of critical process temperatures with improved product quality, rejection losses prevented. Heat is removed at the rate of in-put.

A closed system, dirt free prevents all troubles from bad water; transferring heat to the atmosphere by the evaporation of a very small amount of water solves all problems of water supply or disposal.

Write for Bulletins 120, 135

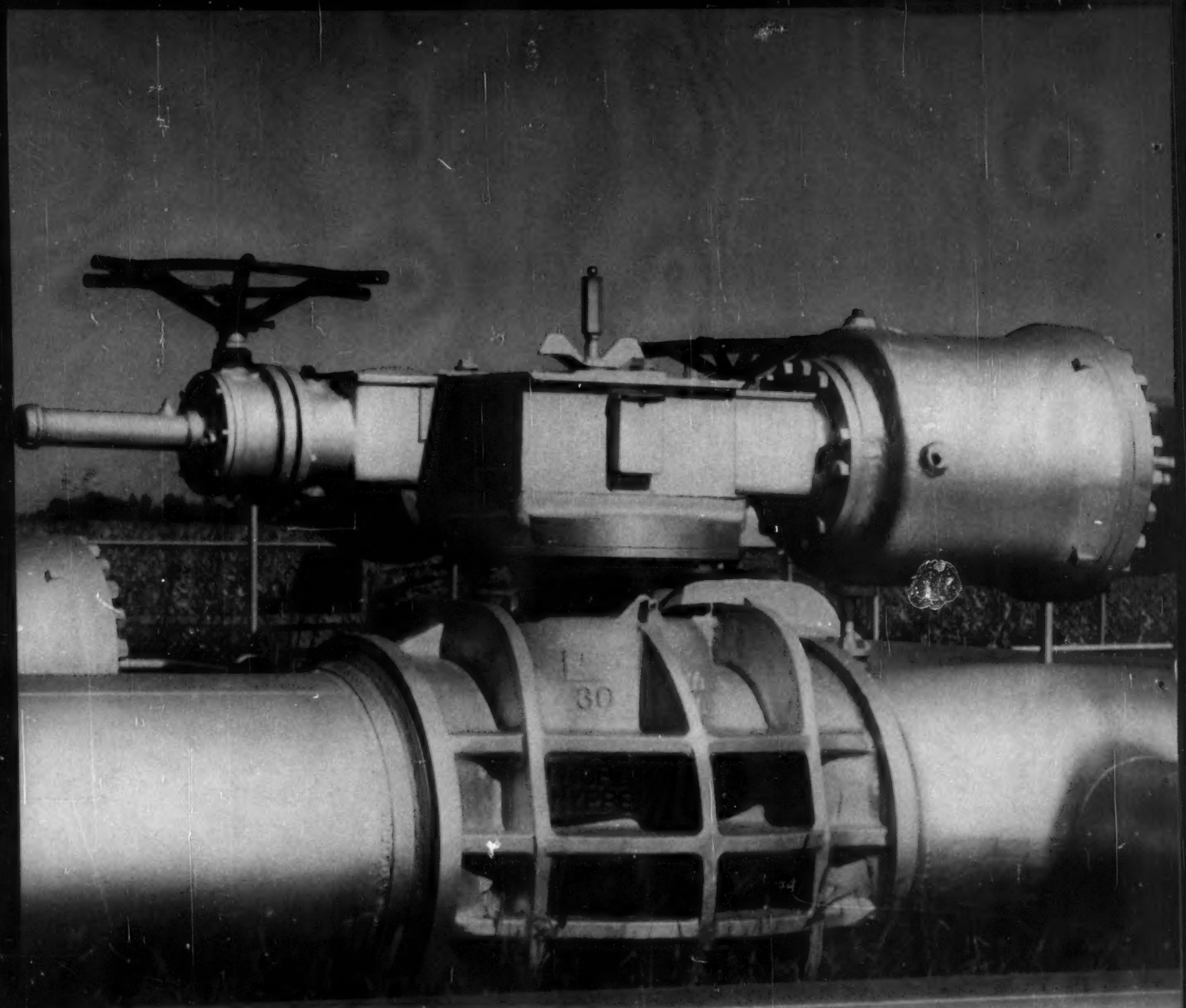
NIAGARA BLOWER COMPANY
Dept. PR-6, 405 Lexington Ave., New York 17, N.Y.
Niagara District Engineers in Principal Cities of U. S. and Canada

EMERGENCY VALVES never have a second chance . . . that's why so many of them are Rockwell-Nordstrom lubricated plug valves. The absolute dependability and positive shut-off that make these valves unequaled for the dramatic services are the same reasons why they will do a better job, longer and at lower cost, on routine services. Rockwell-Nordstrom is the world's most complete line of lubricated plug valves and plug valve accessories. Rockwell Manufacturing Company, Pittsburgh 8, Pa.

ROCKWELL-Nordstrom VALVES

it's **ROCKWELL**

MANUFACTURING COMPANY



HOW FAST WILL IT CLOSE?

Rockwell-Nordstrom valves close much faster than ordinary valves . . . the *lubricated* plug moves only through 90° for *full*, positive shut-off.

Rockwell-Nordstrom is the world's most complete line of lubricated plug valves and plug valve accessories. Rockwell Manufacturing Co., Pittsburgh 8, Pa.

ROCKWELL-Nordstrom VALVES

it's ROCKWELL

MANUFACTURING COMPANY

THE MARK OF QUALITY

BARBER COLMAN

Wheelco Instruments

Don't settle for less... get the best control system for your processing

There's no need to settle for inferior performance or pay a premium for features your processing doesn't require. Wheelco Series 400 Capacitrols, available in six standard control forms, let you choose the indicating controller ideally suited to your processing needs. Get the facts on their proved performance on a variety of installations requiring indicating and controlling of temperatures, voltages, current, speed, and similar variables.

Controls forms you can choose include: two-position, time-proportioning, multi-position, proportional-position, and "stepless" electric proportioning. All of them give you electronic "no drift" control and "plug-in" design for easy maintenance and service.

Ask your nearby Wheelco field engineer for Bulletin F-6314.

BARBER-COLMAN COMPANY

Dept. F, 1597 Rock Street, Rockford, Illinois, U.S.A.

BARBER-COLMAN of CANADA, Ltd., Dept. D, Toronto and Montreal, Canada

Industrial Instruments • Automatic Controls • Air Distribution Products
Aircraft Controls • Small Motors • Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

Who's Building...

extremely rugged terrain of this section of Canada which made necessary considerable earch moving and leveling before construction could begin.

Clark Oil & Refining Co. is building a gasoline cracker for ethylene production at its Anagorna works in Bavaria. The unit may use crude oil at some future date.

Magnolia Petroleum Co. is building a crude distillation unit at Beaumont, Texas. The 100,000-bpd unit will have a tower 166 feet high and 23 feet in diameter. The unit is slated for completion in the fall, and will eventually replace several smaller units at the refinery.

Steelman Gas, Ltd., is building a $20-million natural gasoline plant in Saskatchewan, Canada. Designed to process 20,000 MMcf of gas per day, the plant will produce natural gasoline, sulfur, butane, and propane.

Richfield Oil Corp. has begun engineering design work on a 37,200-bpd crude topping unit for its Watson, Calif., refinery, boosting capacity to 174,000 bpd. The project is slated for 1959 completion. An 18-million gallon benzene and toluene plant is nearing completion at the refinery.

Arkansas Louisiana Chemical Corp., a newly formed, wholly-owned subsidiary of Arkansas Louisiana Gas Co., is planning construction of a gas-liquids extraction plant near Magnolia, Ark. The $3-million plant is expected to produce 80,000 gallons of ethane, 66,000 gallons of propane, and 27,000 gallons of butanes daily.

American Synthetic Rubber Corp. has completed a SBR plant at Louisville, Ky., to produce 25,000 long tons of rubber yearly from butadiene and styrene. Walter Kidde Constructors began construction of the plant in spring, 1956.

Gewerkschaft Erdoel Raffinerie Emsland is tripling the capacity of its 17,000-bpd Lingen-Holthausen refinery. The firm is jointly owned by Wintershall A. G. and Gewerkschaft Elwerath.

N. H. Wheless Oil Co. and **W. C. Feazel Interests** will build a natural gasoline plant with a capacity of 25,000 MMcf-per-day at Tengas Parrish, La. The plant will process gas purchased from the Tengas Gathering Corp. in Jefferson County, Miss., and will be fed by a 12 mile pipe line from the Tengas field.

Cities Service Oil Co. has purchased Liquigas Co.'s Stonewall County, Texas, gasoline plant. The plant produces 75,000 gallons-per-day of natural gas liquids, and handles 15-million cubic feet of gas daily.

Standard Oil Co. of Calif. and **Irving Oil Co., Ltd.,** will build a 36,500-bpd refinery at St. Johns, N.B., on Canada's east coast, with completion slated for 1960. The building will be done by Bechtel Corp. The plant will be operated by Irving Refining Co., Ltd., a subsidiary jointly owned by Irving Oil Co. and Standard Oil Co. of Calif.

For more data on advertised products, use Readers' Service Cards, last page.

It's a fact...

Warren's Service Is Unsurpassed!

WARREN Resources of Production, Transportation and Storage, and WARREN'S Experience as a Specialist in its field assure you of complete and dependable DELIVERIES of . . .

NATURAL GASOLINE

whatever the grade and the volume!

WHERE, WHEN and the WAY you want it!

for QUALITY
QUANTITY
and SERVICE
Rely on . . .

WARREN

PETROLEUM CORPORATION

TULSA, OKLAHOMA • Cable Addresses: STAVOLENE, WARREN

EXPORT TERMINALS: CORPUS CHRISTI, PORT ARTHUR, BAYTOWN, TEXAS CITY AND WARRENGAS, HOUSTON, TEXAS, SAN PEDRO, CALIF.

Communications Can Be Improved—And Here's How

Howard E. Turner
E. I. duPont de Nemours and Company
Wilmington, Del.

Really good communications are not easy to achieve, but here are two "keys" that will open the door to better engineer-management understanding.

RELATIONSHIPS between engineers and management in American industry have traditionally been close and congenial. Many firms were formed by engineers and carry on engineering-based businesses. Engineers also provide one of the most important sources of top management personnel.

Engineering staffs have usually been considered to be well-informed on management aims, policies, and long-range plans. However, the size, complexity and dispersion of engineering and company organizations have been increasing rapidly, particularly since the beginning of World War II. As a result, it has become much more difficult for management to maintain the bonds of communication so necessary to inspire confidence and bring out the best in cooperation from engineers.

A Morale Factor. This is a serious situation. Poor communication not only affects short-term prosecution of work, but it can affect the long-term morale of the engineer and cause him concern regarding his economic position, professional recognition, advancement, utilization of talent and other matters, all adding up to what may be termed "status." Ultimately this may lead to unionization problems, such as experienced in the electronics and aircraft industries.

It is admittedly difficult to measure or define the seriousness of the communications problem. One measure is indicated by a number of surveys of engineers, including questions on how they feel about the effectiveness of communications. The most recent of these was sponsored by the National Society of Professional Engineers and results have been published under the title, "Career Satisfaction of Professional Engineers in Industry." Engineers from 11 large corporations were interviewed and their opinions are reflected in the following:

Question	Years Experience 3-6	10-15	20-25
Does your company keep engineers fully informed on company policy and operations? (Downward communication)	Yes 49%	Yes 67%	Yes 77%
Does your company ask engineers' ideas and advice on policy matters relating to engineering? (Upward communication)	Yes 60%	Yes 61%	Yes 84%

The lower degree of satisfaction indicated in the less experienced groups may mean that management performance on communications is not as satisfactory as people in upper levels of management think it is. It may also reflect that people with less experience generally require more explanation and communications to explain reasons for policies and decisions.

Another indication of the importance placed upon communications by engineers in an organization is shown by the following data from the same survey.

What Could Your Company Do to Help Engineers Achieve Their Full Potential?	
More clerical help and technical help	21%
Better training on the job	15%
Keep us better informed	9%
More association with management	9%
Better supervision of engineers	9%
More recognition for individual achievement	8%
Give more authority and responsibility	6%
Encourage education off the job	5%

You will see that communications stands fairly well up in the list as an area for improvement. If you haven't read the report you'll find it very worth-while reading in regard to com-

munications and other areas of interest.

How Much Time. An auxiliary source of data relating to importance of communications is the amount of time spent communicating in an organization. This indicates the effort spent and its cost, which can be weighed against results, such as presented previously, in order to measure effectiveness of communications. It can also aid in determining which areas should be selected for improvement attention.

Here is a summary of results obtained by an analysis of the activities of the individual engineers in the DuPont consulting organization, to determine how they spend their time. The data were obtained over a period of months by a work sampling procedure called "technical activities analysis."

Analysis of Time Spent

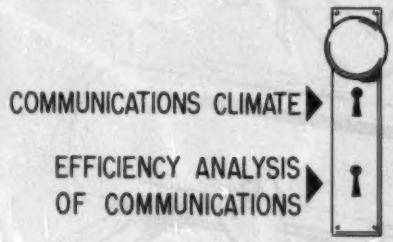
One-Way Communications	
Writing	10.9%
Dictating	1.2%
Sketching	1.1%
	13.2%
Two-Way Communications	
Telephoning	4.1%
Discussions (2, 3 persons)	22.3%
Conferences (more than 3 persons)	7.9%
	34.3%

You will note nearly half of the office time was spent in some form of communication. The Engineering Service division is one branch of the DuPont Central Engineering department. In this division approximately 500 engineers provide consultation and applied engineering assistance in such fields as chemical and mechanical engineering on problems relating to process, equipment, materials improvement and cost reduction. A major portion of their activity is carried out in plants, so most of their office work involves communications and related activity.

Note the large portion of time involved in communications. This emphasizes the significance of this area of work.

In Summary. Engineer-management communications, is one of the most difficult areas in which to satisfy a man, as well as an organization. This is especially true of an engineer who is highly inquisitive and ambitious. Considering this and the importance of communications to short-range and long-range work effort, we should never be satisfied but striving always to find better ways of communicating.

Two 'Keys' to Improvement. Many opinions have been expressed on how communications can be improved. These include such items as specific new techniques, training in existing techniques, reorganization to reduce layers of supervision and assistance from outside organizations. Major improvement lies *not* in taking steps like these, but rather through a broader approach embodying two "keys" to communications improvement.



The first "key" is the development of a favorable communications "climate" or "environment." The second "key" is an "efficiency analysis" of each communication instance in our present system to improve its effectiveness. Let's discuss these in turn.

As far as the first key, "favorable climate," is concerned, the primary requisite is generally present in that most people have an inherent desire to communicate. This, however, is latent to a considerable extent, needing both external encouragement and self-encouragement for effective development. For example, engineers, may feel reluctant to approach supervision on a matter, feeling the first move is up to the supervisor. This need not be so. If an approach is reasonably timed, an efficient oral or written contact on a problem will be welcomed; and a prompt answer should be expected. Taking initiative through such steps is a major responsibility in developing a favorable atmosphere.

Supervisors likewise share the responsibility in this area, and must spend time with their engineers getting to know them and their work. This helps establish two-way communications and thereby encourages a favorable communications climate. Helpful techniques include:

1. Lunching together
2. Attending appropriate meetings
3. Taking trips together

Be Available. One of the most effective factors in encouraging people to communicate is to "always have a minute" for discussion of a problem. If other people find that your door is *really* open and you answer your phone, they soon learn and the word gets around that you are "available." This means many interruptions, but it is definitely helpful in promoting a favorable communications climate. And—it makes an over-all contribution to getting the work done.

Another way to encourage communications is to be alert for significant work accomplishments by others with whom you should develop better communications. Then a personal discussion on the subject with the person involved makes him aware of your communications desire and exchanges beneficial information, "killing two birds with one stone."

In addition to continual emphasis at all levels, certain techniques are helpful from an organizational standpoint. DuPont's two-day annual meeting this year included small discussion groups of engineers only, covering the subject of "Professional Development." Their suggestions and recommendations in the area of professional recognition were very frank and helpful. As a result, the company is taking definite steps in providing better working conditions and improving recognition.

Encouragement of technical society participation is, of course, a part of the communications climate, and is our responsibility both as engineers and supervisors. Another facet of communications which should be considered at this point is the technical journal. No other form of communication offers so much information to so many engineers.

Desire Into Action. If supervisors and engineers alike continually translate their desire for effective communications into actions demonstrating this desire, they will create a dynamic, favorable communications climate, the first "key." Only continual consciousness and emphasis will solve this first half of the problem.

The second key to communications, "efficiency analysis," is aimed at making existing methods more effective through analysis of each communications instance similarly to the way an engineering problem is solved. This means that each opportunity to communicate should be *determined, analyzed* and *acted upon* by answering such questions as:

1. What subjects, if any, should be communicated?
2. To whom should it go (directly, indirectly)?
3. What is the required timing?
4. What communications medium will be most efficient of time (of sender, receivers)?
5. How can all essential material be covered most efficiently?

With creative thought beforehand and follow-up afterward to determine results and possible improvements in future communiques, existing communication methods can be significantly improved, without diluting efforts by trying to find new methods of communicating.

In outlining how existing communications can be analyzed and improved, consider specific case examples under the three necessary types of communications. These are downward, upward, and sideways or horizontal communications.

Downward Communications. These are very important to morale of the individual because if he does not understand a subject that concerns him, nor the reason "why," he is bound to be dissatisfied. By employing the analytical approach, specific cases have shown that communication through multiple layers of supervision frequently results in a garbled and warped story reaching the engineer after much passage of time.

To overcome this, it is helpful in many instances to promptly issue a written statement to all concerned explaining the why and including all information that they may need as well as want to know.

Sometimes first-hand discussion at the immediate supervisory level is necessary to enable questioning. Then the supervisor should be supplied with all information deemed necessary and, in addition, encouraged to consider and ask for any additional information that he feels necessary. Feedback of questions and later actions not in accordance with information transmitted should be analyzed to determine where communication broke down and how future communiques can be improved.

Earlier, the activities analysis made of our technical work was mentioned. This was the first stage of the efficiency analysis, the second "key." When DuPont found so much time was spent in meetings and discussions, it was considered of primary importance to determine how effectiveness could be improved. The company decided to give group supervisors a refresher course in discussion leading. In addition emphasis was placed on their particular responsibility for maintaining effectiveness of meetings because they are included in a majority of them.

It worked! In follow-up contacts with them, it was found that they were reducing time spent in meetings by keeping them more "on the beam." Other meetings have been avoided by written dissemination of information.

Upward Communications. Here is another phase vital to all of us, in order to keep management promptly advised of important technical, business, and personnel developments for appropriate action. Each engineer should know his supervisor's views and opinions so they may be taken into account in formulating courses of action.

You have a definite responsibility to contribute ideas on important problems. These should, of course, include constructive recommendations. Here again you should analyze the situation utilizing the second "key" approach to determine how best to communicate. Feedback of results and actions should guide future methods.

The secret of successful communications upward is to decide what information the next and possibly subsequent levels of the organization want and need. Then supply it in the form that can be most efficiently handled and least likely to be misinterpreted or questioned—all of this commensurate with the urgency of the situation.

Where at all possible, it is probably best to give your superior two copies of a clear, concise memorandum outlining the problem with a recommendation for action. He can digest the memorandum when convenient, which is usually prompt if the memorandum is brief. He can then use one copy for initiating action, frequently through another person who sees your original thoughts. The other copy can be used as a follow-up and later filed.

Upward communications through multiple layers of supervision encounter the same problem as downward communications in preventing a garbled and warped story from reaching management. Occasionally, increased span of supervision is recommended to minimize supervisory layers and thereby decrease communication problems. However, organizational structures are generally set by work objectives and business needs, so effective communications must be accomplished within existing structures by analyzing and improving existing communication paths.

Horizontal Communications. In the area of engineer-management relationships, there is also need for horizontal communications. Engineers need an opportunity to discuss among themselves their technical and procedural problems to improve effectiveness. Through an analysis of this problem, DuPont has initiated such techniques as (1) the annual meeting discussion groups, mentioned earlier, (2) periodic technical reviews where a few engineers briefly present a review of their work to an entire section, and (3) periodic engineer attendance at weekly section staff meetings, where the engineer outlines his work and also gains understanding of policy discussions.

The engineer also shares responsibility for horizontal communications. Follow the stepwise analysis procedure of the "second key" to determine where and how you can improve effectiveness and contribute in this area. One phase for careful consideration is the place of the professional society in communications.

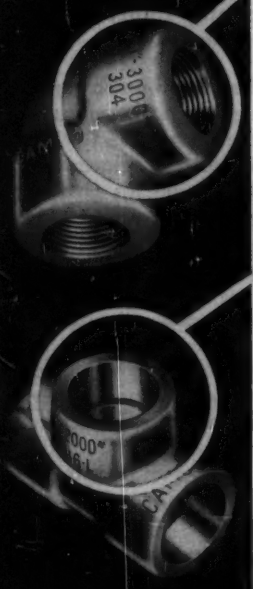
Most of you know that the NSPE Committee on Employment Practices has recognized the need and the opportunity for the professional society to serve in this area. It can serve not only the professional engineers which compose its membership, but also the users of engineering services through

For QUALITY... SERVICE and AVAILABILITY -- *specify*

THE *Quality* LINE IN STAINLESS

CAMCO

SCREWED and SOCKET WELD STAINLESS STEEL FITTINGS



SCREWED END FITTINGS

150# . . . All cylindrical fittings to 2" IPS inclusive are machined from solid forged and wrought materials. Higher sizes are machined from sound quality castings. Unions 1¼" IPS and over have octagonal ends.

2000#, 3000# and 6000# . . . Machined from solid drop forgings and are recommended for use where severe pressure-temperature conditions are encountered.

SOCKET WELD FITTINGS

2000#, 3000#, 4000# and 6000# . . . Machined from solid drop forgings and wrought materials and are recommended for use where severe pressure-temperature conditions prevail and permanent pipe connections are desired. Furnished with a wide reinforcing band extending beyond the depth of the socket.

CAMCO also manufactures a complete line of Flanges to MSS and ASA Standards.

One source for all your Stainless Steel Fitting Requirements.

Available upon request, literature and address of local distributor.

CAMCO PRODUCTS, INC.

NORTH HAVEN, CONNECTICUT

WEST COAST AGENT AND WAREHOUSE

J. J. GATELEY
8283 Baldwin Street
Oakland 21, California

which the skill and knowledge of the individual engineer is used for the betterment of mankind.

The services of NSPE including published information covering studies of employment conditions of engineers plus meetings of the national and local societies afford a valuable means of improving horizontal as well as vertical communications. The foregoing very briefly summarizes the policy statement on this subject adopted by the NSPE Board of Directors in Dallas, in June, 1957.

If you have not read the policy statement, see the September 1957 issue of *American Engineer*.

Thus, in communications downward, upward, or horizontally, the "second key" to improved effectiveness is continual analysis of existing communication procedures by engineer, as well as supervisor.

The DuPont Company has no easy answer to the communications problem. I have mentioned a few techniques utilized, but largely to illustrate the "efficiency analysis" procedure. The one thought you should get from reading this is the answer to the communications problem lies *not* in specific techniques, but in two key requirements:

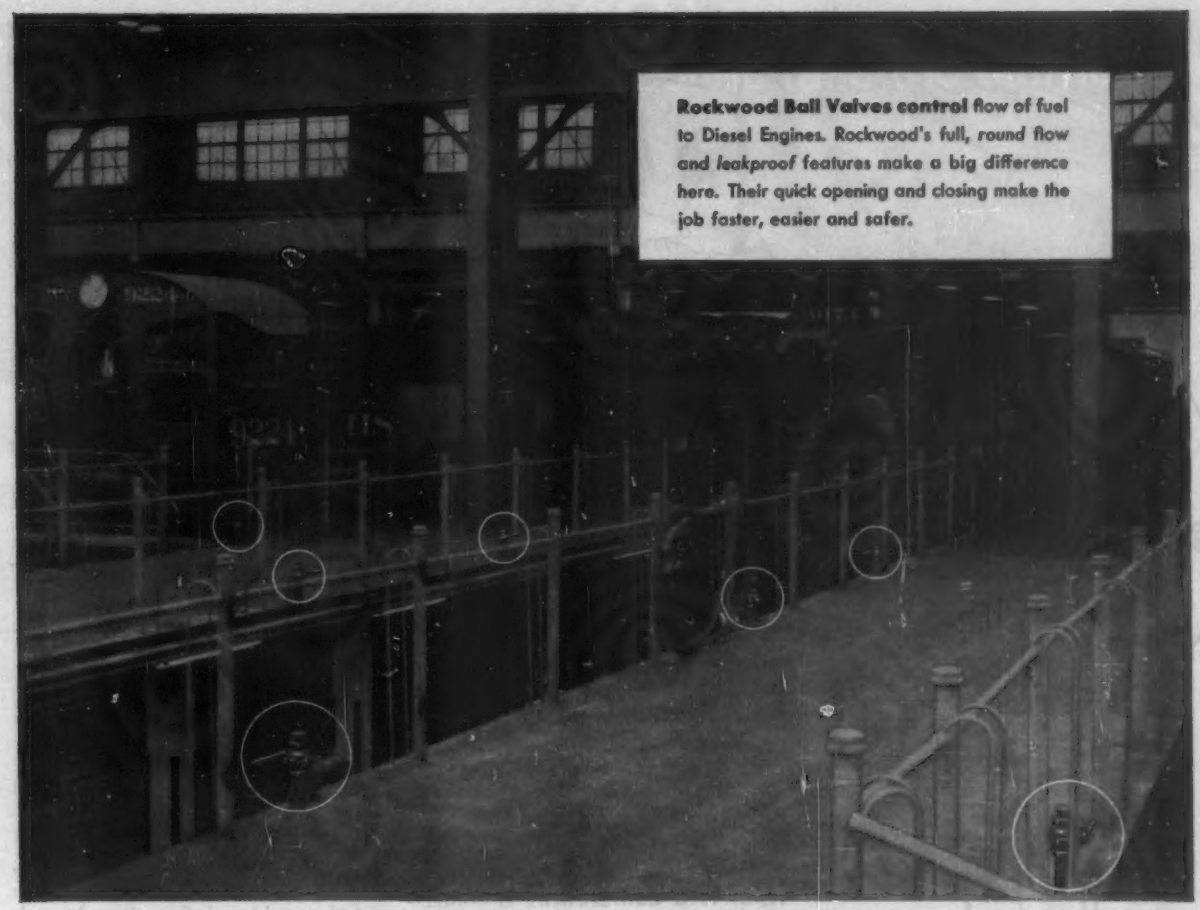
- Favorable communication climate
- Efficiency analysis of specific communication instances

If engineers and engineering supervisors, really focus their attention on these two "keys"—and are creative in the solutions, they can make a major contribution toward advancing the status of the profession.

About the Author

Howard E. Turner is a director of consultants in the field of chemical engineering. He has been with DuPont Co. for 17 years. During this time he has held field engineering and supervisory positions and has been field section manager of engineering personnel at several Du Pont industrial chemical plants. Turner received his B.S. and M.S. degrees at the University of Minnesota where he taught for two years before joining DuPont.

For more data on advertised products, use Readers' Service Cards, last page.



Rockwood Ball Valves control flow of fuel to Diesel Engines. Rockwood's full, *round* flow and *leakproof* features make a big difference here. Their quick opening and closing make the job faster, easier and safer.

Flammable liquids handled with safety ... without leakage... without delay

Rockwood Ball Valves are ideal for handling flammable fuel oils. They handle quickly, easily! The reasons are —

Rockwood Ball Valves with *Full Round Flow* eliminate turbulence and provide minimum friction loss.

Only a quarter turn is needed to open or close the valve.

Rockwood Ball Valves have a chrome-plated ball that holds up under tough abrasion, pitting and scratching — that means *Long Wear-Resistance.*

Rockwood exclusive corrugated spring design and the pressure of the fluid *automatically* position the ball against the seat for a completely *Leakproof Seal.*

These features pay off on handling fuel oils. Rockwood Ball Valves deliver flammable fluids at the volume you want quickly, without leakage and a minimum of maintenance. The only other thing you could ask for is more information — and the coupon below will get it for you.

Tested and listed by Underwriters' Laboratories, Inc. Distributors in principal industrial areas.

ROCKWOOD BALL VALVES

FULL, ROUND FLOW

ROCKWOOD

ROCKWOOD SPRINKLER COMPANY
2221 Harlow Street
Worcester 5, Mass.

Send me illustrated folder V-4 on Rockwood Full-Flow Ball Valves.

Name.....
Title.....
Company.....
City.....
Zone..... *State*.....

For more data on advertised products, use Readers' Service Cards, last page.

Rate Yourself as a Conference Leader

Dr. Robley D. Stevens
Management Consultant, Washington, D.C.

YOU HAVE just emerged from a conference where you and your associates spent three hours in stimulating discussion, and where a good workable solution was found to your refinery's problem.

You think of how different it was from the one last week—the one that started 30 minutes late and where most of the time was spent in hashing out trivial matters and losing sight of the real problem. Nothing was really settled and when it was time to leave there was a mad scramble for the door and the general feeling of, "whew—I'm glad that's over."

Why, though, should there be so much difference in meetings? Why are some so fruitful while others are for the most part failures? Obviously the leader is the big factor, and regardless of how it may appear to you, a successful business conference doesn't just happen—it is the result of careful planning and thoughtful leadership.

What Is a Conference? A conference is a meeting for finding answers to a question or solutions to a problem. It is a pooling of the knowledge and experience of a group of individuals. Of course, all conferences, then, are meetings with a definite purpose or objective, but not all meetings are conferences. The difference is well worth examining.

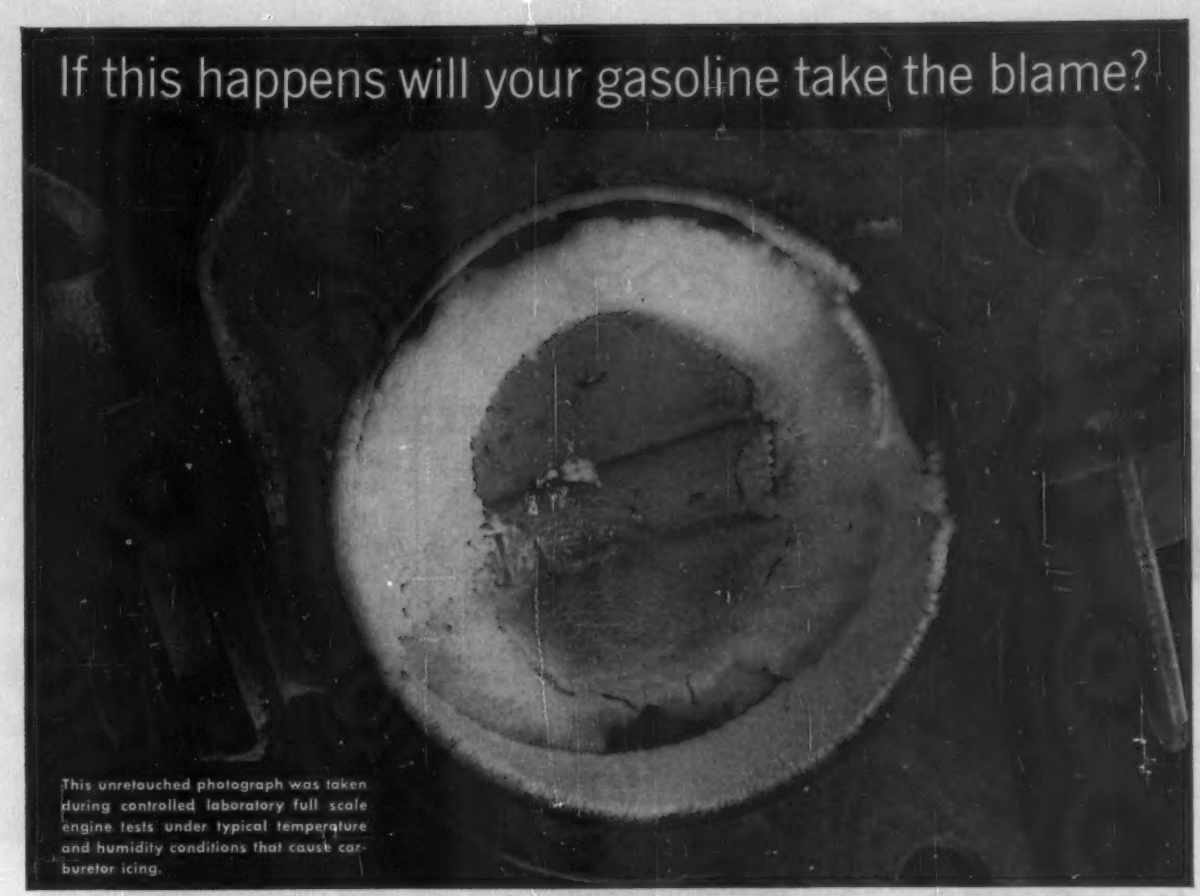
Obviously, there must be a discussion as well as an objective in every business conference so that a decision will be reached. However, in every well-conducted business conference, the conclusion or solution should be based on a complete and thorough investigation of all phases of the topic or problem under discussion, as this promotes clear thinking among those who participate.

A conference with a real problem should adapt itself to group discussion—it must present a challenge—and solving the problem should be a satisfying experience to the group.

You—The Leader. What, exactly, are some of your duties as the conference leader? What is expected of you? Obviously, the first thing you must do is to get the conference started. As the leader, you should tell your group the purpose of the conference. You should demonstrate that it is a real business problem, perhaps, an urgent refinery problem. If you put the problem before them in such a way you will arouse their interest, motivate their thinking, and create in each of them a desire to do something about the problem.

You don't have to be a genius or superman to be a good conference leader but there are certain traits which are desirable. For instance, you must enjoy working with people. You should have confidence in your group and be convinced it can carry on an intelligent discussion and arrive at a logical solution. You should be able to express your thoughts clearly and in a language which your group can understand. You should be able to think rapidly and clearly. You must keep a step ahead of it, sense its trends, and see where the discussion is heading.

Everyone who works with people in a refinery, and particularly one who leads them, can find that a sense of humor is a real asset. Pointing to the lighter side of a problem will often relieve a tense situation. Thus, you should make full use of your talents, and, realize that self-restraint, tact, courtesy, and patience will help you. Your own zest and enthusiasm should


If this happens will your gasoline take the blame?
This unretouched photograph was taken during controlled laboratory full scale engine tests under typical temperature and humidity conditions that cause carburetor icing.

Save That Customer! UNICOR®-LHS PREVENTS CARBURETOR ICING

If carburetor icing happens to stall the car of one of your customers this winter he'll probably cuss out your gasoline, rather than the temperature and humidity conditions that are the real culprits. Keep him happy, and his car rolling, by treating your product with UOP's anti-icing compound, Unicor-LHS. This is a completely new compound, the most effective anti-icing agent yet developed. It is easy to apply and economical to use. Here are its advantages:

Most potent anti-icing agent: Unicor-LHS is an anti-icing agent, not just a de-icer. It prevents ice formation and is about 40 times as effective under severe carburetor icing conditions as the widely-used alcohol type.

No gasoline dilution: Because it is used in very low concentration Unicor-LHS causes no significant loss in BTU value of gasolines, a primary disadvantage of ordinary de-icing compounds.

Convenient and economical: Only small amounts of Unicor-LHS are required . . . less than half the cost of alcohol. No large scale storage or blending facilities needed. It can be applied anywhere from refinery to jobber or filling station.

Not water soluble: Not soluble in water, Unicor-LHS (light hydrocarbon soluble) is completely and instantly miscible in even the lightest components of high vapor pressure winter-grade gasolines.

Available right now: Write our Products Department for samples or for commercial quantities. We'll be glad to advise you on the most economical way to use Unicor-LHS.

Unicor-LHS is also an effective rust and corrosion preventative. Protects refinery processing equipment, distribution and storage facilities all along the line from the refinery to the final distribution point.

UNIVERSAL OIL PRODUCTS COMPANY

30 ALGONQUIN ROAD, DES PLAINES, ILLINOIS, U.S.A.

More Than Forty Years Of Leadership In Petroleum Refining Technology

Note rugged branch construction on this massive oil header fabricated with a length of pipe and five 30 x 12 and two 30 x 30 weldolets.

BIG PIPE BIG MONEY to be SAVED by using 30 x 30 BONNEY WELDOLETS

Closer manifolding, ease and speed of field fabrication without header distortion, lower purchase and welding costs are just a few of the profit benefits of header fabrication with Bonney Weldolets. Today there is particular need for reducing costs. Bonney Forge can provide this opportunity for cutting costs in your company. Write, phone or wire for details.

BONNEY

WELDOLETS®
THREDOLETS®
SOCKOLETS®
ELBOLETS®
BRAZOLETS®

CARBON STEEL
STAINLESS
ALLOY
for all services

BONNEY FORGE AND TOOL WORKS

Dept. M

ALLENTOWN, PENNSYLVANIA

be real, apparent, and contagious. You must get the individuals to work as a group so a solution to the problem will be found.

You and the Problem. You must consider the facts and conditions of the problem to arrive at an accurate appraisal of the situation. In defining your refinery business problem, you should consider criteria for evaluating results. These criteria are the yardsticks for measuring your solution. For instance, ask yourself these pertinent questions:

Will this solution produce the desired results?

Will it actually do the job?

Does our refinery have the means for accomplishing the job this way?

Is the solution going to cost our refinery too much?

Can we afford it?

You will have to rely on your good judgment and common sense to tell you when you have sufficient information to give you a clear picture. You will use refinery sales reports, production charts, cost analysis figures, special studies, etc. as among your tools, but guard against gathering too much irrelevant data.

Now you should consider the solutions to your problem. After you list all possible solutions, consider the implications of each. This is the "If I do this, what will happen?" approach. If, of course, the solution you select passes the test, you have solved your problem.

Ask Questions. The success of your conference will depend to a large degree on your asking the right question at the right time. A direct question enables you to draw out information from your group. You will need follow-up questions to keep your business conference going. The primary purpose of your questioning is to encourage group thinking on the topic or problem. Thus, you will have to consider the effect of your question by asking clear and concise questions and, avoiding anything vague, indefinite, and ambiguous. In short, let your questioning be natural—don't think yourself a quiz master who knows all the answers.

Getting Ready. Obviously, you are unable to conduct a refinery business conference without a group and a room. You should have good com-

For more data on advertised products, use Readers' Service Cards, last page.

THE MARK OF SOUND

REFINERY ENGINEERING

THIS is the mark of McKee engineering. To oil men all over the world it means sound process and plant design, thorough, efficient engineering and construction. McKee's reputation for building plants that earn profits is backed by an organization with the experience and ability, the scope and resources to undertake your complete refinery project under a single contract.

McKee
ENGINEERING & CONSTRUCTION
Services

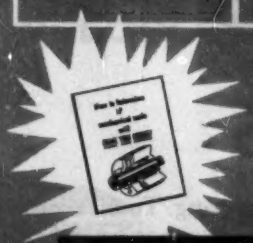
Arthur G. McKee & Company • Engineers and Contractors
Headquarters: McKee Building • 2300 Chester Avenue • Cleveland 1, Ohio
Offices: New York, N. Y. • Union, New Jersey • Washington, D. C.
British Representatives of Metals Division: Head, Wrightson & Co., Limited
Canada: Arthur G. McKee & Company of Canada, Ltd., 372 Bay St., Toronto

How to determine if mechanical seals will SAVE YOU MONEY

Mechanical seals can play a vital, *often unsuspected* role in the economics of your plant operation.

FOR EXAMPLE—

PRODUCT LOSS	Eliminating gland leakage prevents loss of valuable products . . . which could be substantial over a period of time. **How much would you save?**
TIME	Maintenance personnel time is minimized . . . and labor costs required to clean areas around leaking glands are eliminated. **How much would you save?**
INVESTMENT	You protect your overall investment by doing away with the prime trouble spots in handling dangerous, noxious, corrosive products. **How much would you save?**



FIND OUT HOW MUCH YOU CAN SAVE!

Send for your free do-it-yourself Cost Analysis Bulletins. See for yourself exactly how you can reduce Product Loss—Save Time—Protect Investment.

SEALOL

SEALOL CORP, 176 Post Road, Providence 5, R. I.

Please send me Cost Analysis Bulletins.

Name..... Title.....

Company.....

Street.....

City..... State.....

fortable chairs, a large table, and sufficient paper, pencils, ash trays, etc. It's also a good idea to have a blackboard. An important advantage of this careful and detailed preparation is the confidence it gives you as the leader.

If you expect your conferees to study the problem before they come to your conference, you should prepare an agenda which might contain the following:

A statement of the refinery problem.

A definition of it.

Your proposed plan of attack.

Be Prepared for Everything. Of course, anything can happen. No one can tell you exactly how you must handle trying or delicate situations which may arise. Much depends on your group, on you, and on the circumstances involved. Thus, you should not be totally unprepared.

You will be dealing with people—many different types of personalities. So you will have to skillfully handle such persons who won't talk; those who talk too much; the know-it-all; those who may oppose you; and the group who reaches the wrong conclusion.

After you have lead a few conferences in your refinery, you will want to learn what progress you have made. Of course, you should, if possible at all, compare yourself with other people who have lead a business conference. Thus, you should constantly check yourself, your preparation, and your performance. It's up to you to correct your own deficiences.

Evaluate Yourself. The self-rating chart listed below will aid you in making a detailed self-examination of yourself as a business conference leader. Place a check-mark by all questions you can answer with an unqualified "yes."

CONFERENCE LEADER EVALUATION GUIDE

Your Preparation
Did you . . .

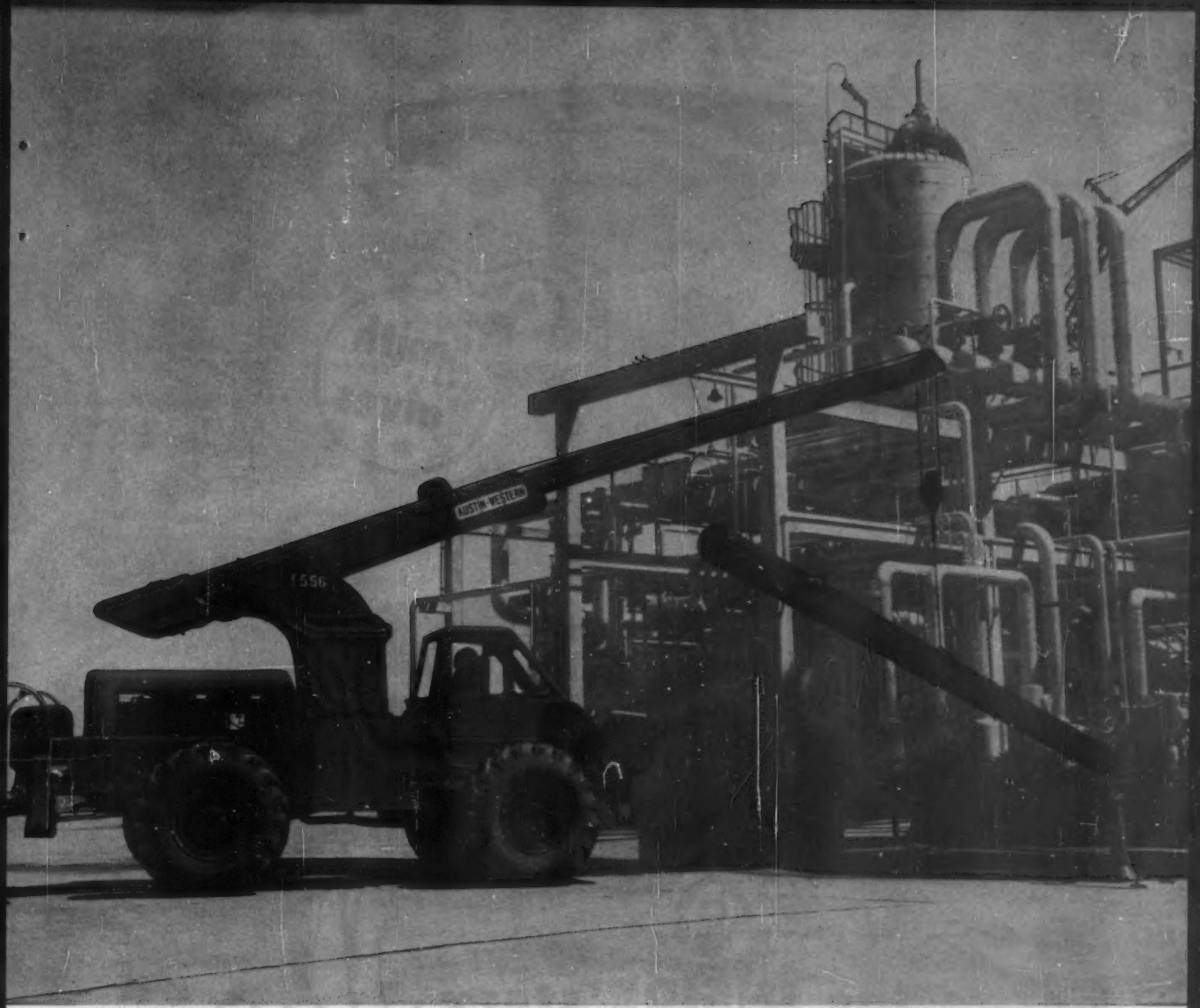
—do a good job of planning and arranging the physical setting?

—make sure the conference started on time?

—check to see if you could adapt some of the refinery training aids to the problem to be discussed?

—feel you had sufficient knowledge and background data?

Continued on Page 251



One of 7 Austin-Western hydraulic cranes at Tidewater Oil Company's new Delaware City refinery shown hoisting a section of pipe at a catalytic cracking unit.

AUSTIN-WESTERN HYDRAULIC CRANE

One of Tidewater's most versatile construction and maintenance tools

Thirty-six Austin-Western hydraulic cranes helped build Tidewater's giant refinery near Delaware City, Del., and seven are now steadily employed handling materials and speeding repairs. They are among the most versatile construction and maintenance tools Tidewater has, and new jobs are being found for them every day.

Here are some of the ways Austin-Westerns save time and money on refinery operations: they remove heat exchanger heads and tubes quickly, eliminating the need for a larger crane or chain blocks; lift and transport pumps into the machine shop for repairs, spotting them precisely; unload freight cars, using their long, live booms fast and efficiently; transport materials with ease under lines in pump alleys and around pumphouses, over railroad tracks, in and out of buildings.

Find out how the flexible Austin-Western hydraulic crane can help you. See your nearby distributor or write direct.

Austin-Western CONSTRUCTION EQUIPMENT DIVISION, AURORA, ILL.

BALDWIN · LIMA · HAMILTON

Power graders • Motor sweepers • Road rollers • Hydraulic cranes

BALDWIN BLH LIMA-HAMILTON

(large photo) Smith "Figure 800" OS&Y Gate Valve
Sizes: ¼"-2" incl.

Here's the INSIDE story . . . . .

If you could look inside each and every SMITH Forged Steel Valve, you would find there a combination of special features, designed manufactured and assembled with watch-like precision to meet the exacting requirements of the Refinery, Chemical and Petrochemical Industries. You would see that here was a valve built to "take it" — to solve the problems of resistance to ever-increasing pressures, temperatures and corrosion — to give longer, trouble-free life in service at lowest maintenance cost.

A large percentage of the major Refineries, Chemical and Petrochemical plants both in this country and Canada now use and approve SMITH Valves. It will pay you to take a leaf from their book of experience and write today for our catalog giving the "inside story" on SMITH Forged Steel Valves.

1 Smith "Figure 850" Inside Screw Valve Sizes: ½"-2" incl.

2 Smith "Figure 815" Flanged End Gate Valve Sizes: ½"-2" incl.

3 Smith "Figure 100" Needle Globe Valve Sizes: ⅛"-½" incl.

4 Smith "Figure G80R" Globe Valve Sizes: ½"-2" incl.

NEW ENGLAND VALVE Corporation

P. O. BOX 1047 • WORCESTER, MASSACHUSETTS

West Coast Distributors: BETHLEHEM SUPPLY CO., LOS ANGELES, CALIFORNIA

Your Personal Qualities
Did you . . .

—feel poised, confident and in control of the group at all times?
—remember to talk so you could be heard and understood clearly?
—quickly grasp and develop pertinent points?
—feel actual enthusiasm and interest in the problem?
—see that the group generally 'followed" where you lead?
—get along with all the conferees?

Your Leadership Techniques
Did you . . .

—arouse and sustain a lively interest in the problem and the quest for for its solution?
—make sure there was group understanding on all important issues?
—see that the discussion was not dominated by a few individuals, and that all members had the opportunity to express their views?
—state all of your questions clearly and concisely?
—keep the discussion on one point at a time?
—handle over-aggressive members skillfully?
—talk to the group rather than to individuals?
—refrain from lecturing?
—distribute the time so that minor issues did not get more time than they were worth?
—see that the group covered all essential items and issues?
—feel that the response indicated the conferees were really thinking about the problem?
—briefly sumarize all important decisions just before the end of the conference?

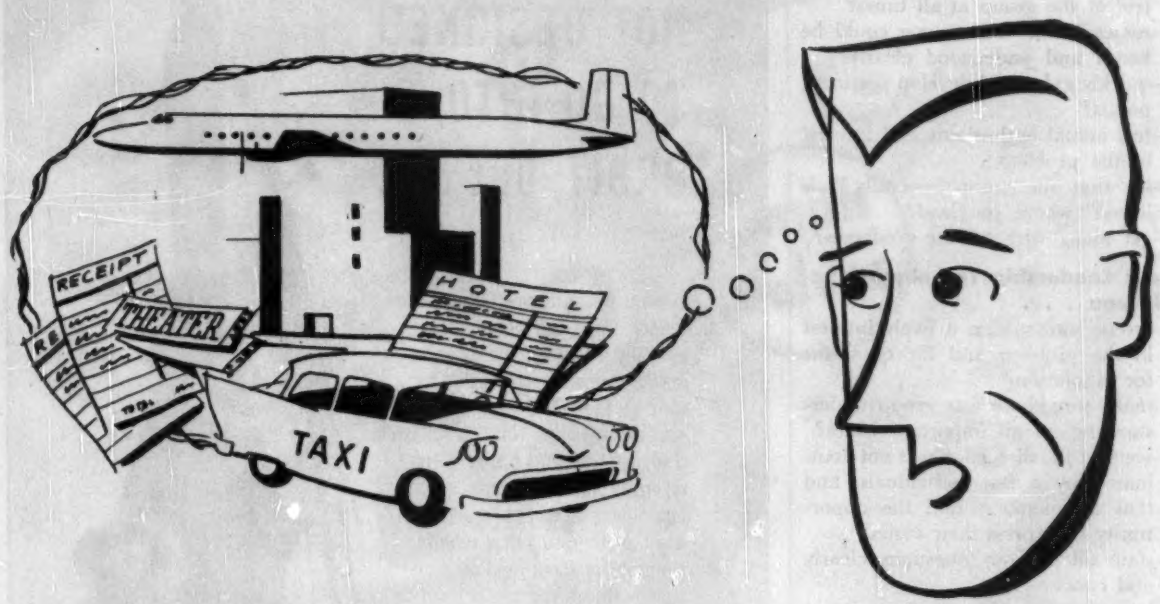
The Results
Did conferees . . .

—solve the problem or reach any conclusions on how it could be solved?
—seem reluctant to leave?

Now you have a picture of yourself as a business conference leader. How do you rate? You shouldn't be satisfied with anything less than a definite and honest "yes" answer for every one of the questions.

Keep this rating and before you lead your next conference, refer to the list and make sure that you are well prepared. Then afterward, refer to it again to see how much you have improved. Remember, if your conference is good, and as its leader will share the prestige of that success. ##

NOT DESIGNED TO GO INTO ORBIT, but . . .
. . . it looks like a missile designed to launch a new satellite, doesn't it? Actually it's a steel vortex and stack fabricated and erected by Chicago Steel Tank Company several years ago. No, C.S.T. hasn't designed or built I.C.B.M.'s, but when it comes to process equipment we can build and field erect anything you may require. No problem about rigid code specifications. You can be sure of expert workmanship with all types of steels and alloys. Find out for yourself how the C.S.T. team can help you. Write for your personal copy of our facilities brochure today.
Custom fabricators and erectors since 1899
CHICAGO STEEL TANK COMPANY
division of U.S. INDUSTRIES, INC.
SALES OFFICES: 6400 W. 66TH STREET • CHICAGO 38, ILLINOIS • PO-7-8900
51 E. 42ND STREET • NEW YORK, N. Y. • MU-7-9298



Start Planning Those Tax Deductions

Next year the expense accounts of oil men will be in for closer examination. Here's how you can avoid trouble and get maximum deductions.

Paul Lockwood
Richmond, Calif.

TAX EXPERTS are betting that the Internal Revenue Service will "lower the boom" on entertainment and travel expenses next year. The disputed line 6 (a), which serves as a "red flag" to call the attention of the investigators to this amount, was rescinded at the eleventh hour for 1957 returns. A recent Internal Revenue Service ruling has been released that will apply to 1958 income tax returns.

Here are some questions and answers about things you will need to do to be in the clear on this item and to get the maximum deductions on your income tax return next year:

Does everyone have to report expenses on income tax returns?

No. If you account to your company or employer for travel and entertainment expenses and are reimbursed, you do not have to report this on the tax return. All you need to do is state that the amount advanced or reimbursed was not more than the amount spent.

As a general rule, the Internal Revenue Service takes the accounting to the company at face. They feel that if the company has approved the expense they know it was business connected and that it was paid. The recent rulings indicate that the employe who has accounted to his company will not be required to substantiate this expense on his tax return.

Employes and executives who do not account to their employers for travel and entertainment expenses will be required to report this information on their next year's income tax returns.

What business expenses can be deducted?

Any and all business expenses of travel and entertainment can be taken as an income tax deduction. However, you must be able to prove that:

1. You actually paid the travel and entertainment expenses claimed.
2. That the expenses were not personal, but for business purposes.

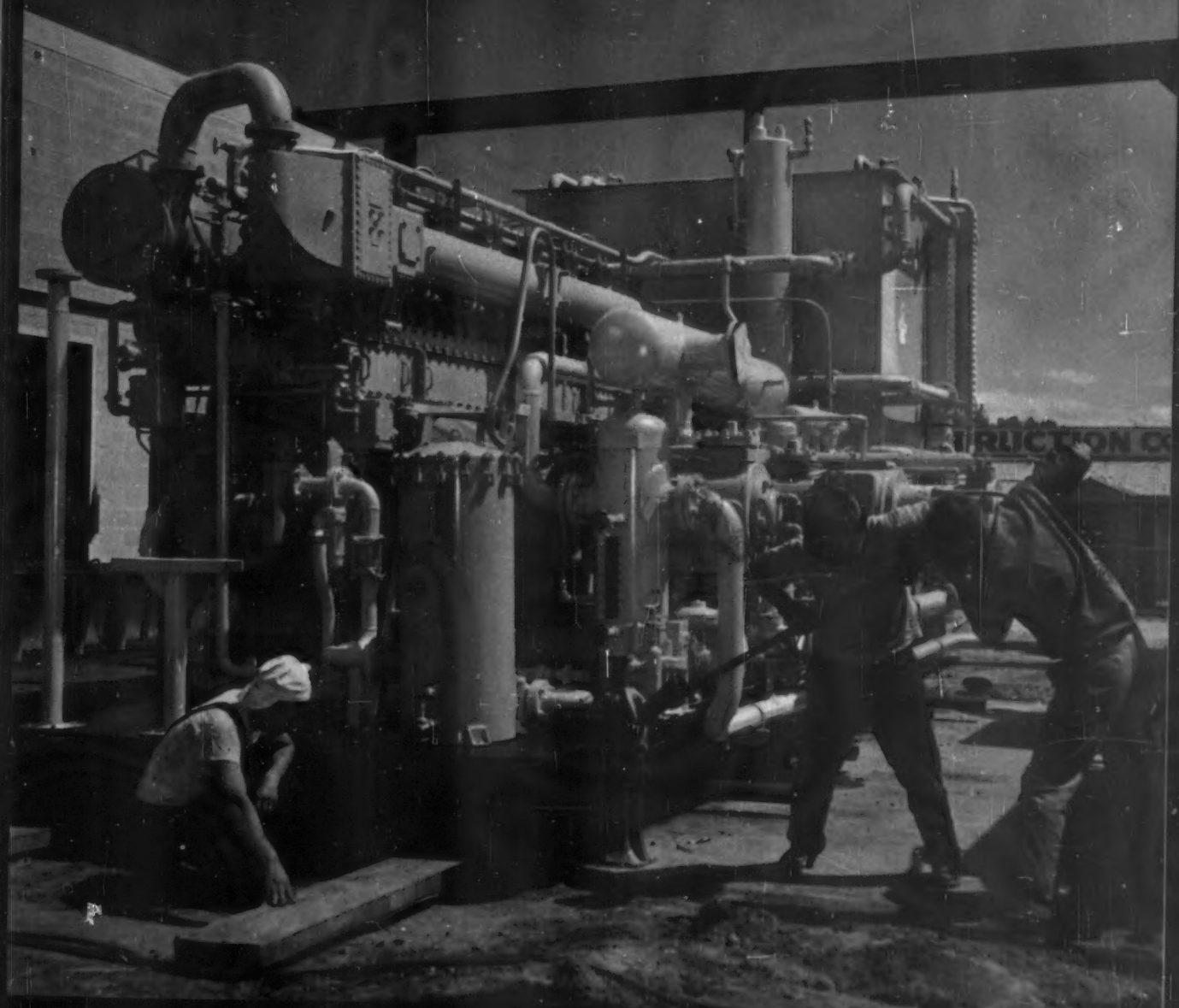
As you can see, these two requirements are the main reasons the Internal Revenue Service is checking entertainment and travel expenses so closely. And, they are checking on these two things . . . actually paid and for business purposes.

What are the requirements for a business expense?

There is no hard and fast rule on

Don't pay today's prices for yesterday's engines!

Read on following pages how the new Worthington SLHC engine compressor can substantially reduce your gas handling costs



Only SLHC Turbocharged Gas-Worthington offers all these

MODERN DESIGN

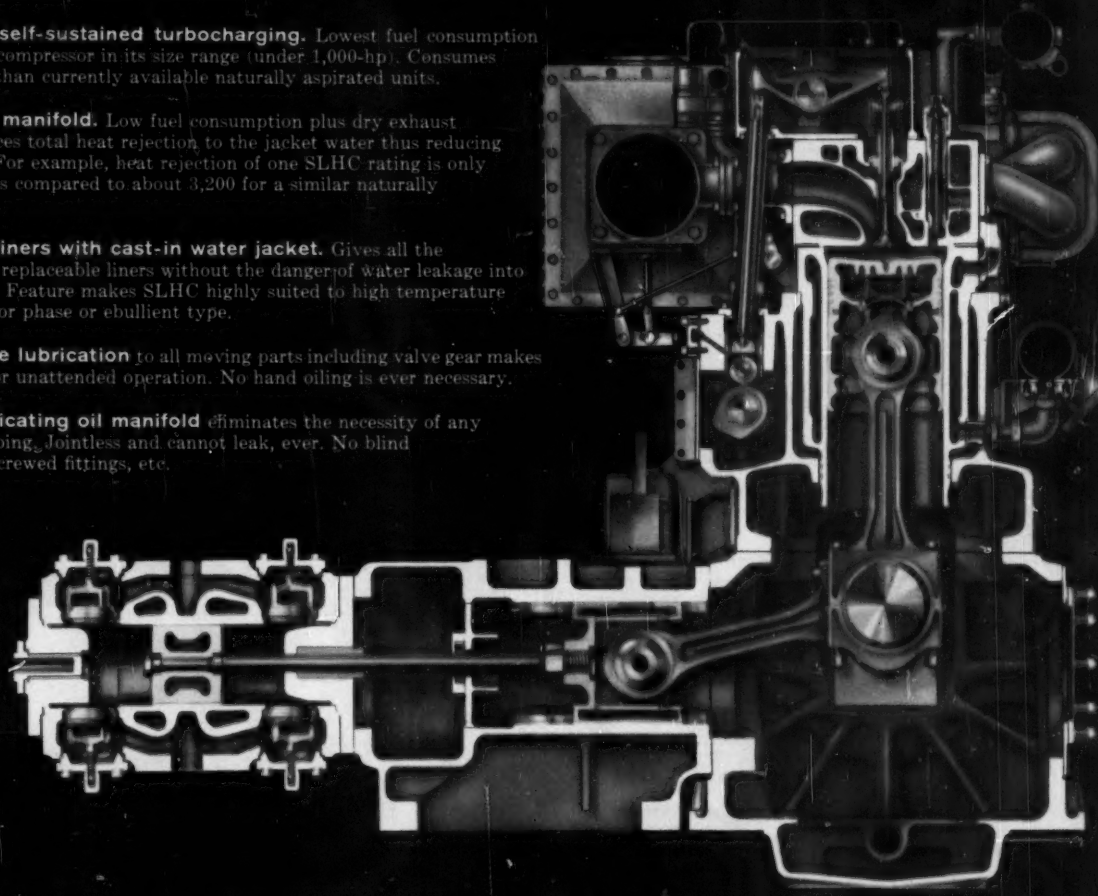
Completely self-sustained turbocharging. Lowest fuel consumption of any engine compressor in its size range (under 1,000-hp). Consumes 20% less fuel than currently available naturally aspirated units.

Dry exhaust manifold. Low fuel consumption plus dry exhaust manifold reduces total heat rejection to the jacket water thus reducing radiator size. For example, heat rejection of one SLHC rating is only 2,015 BTU's as compared to about 3,200 for a similar naturally aspirated unit.

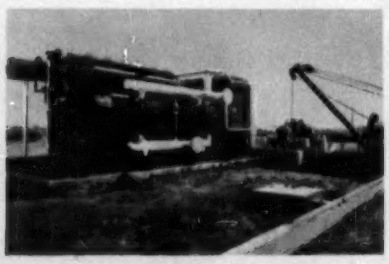
Removable liners with cast-in water jacket. Gives all the advantages of replaceable liners without the danger of water leakage into the crankcase. Feature makes SLHC highly suited to high temperature cooling of vapor phase or ebullient type.

Full pressure lubrication to all moving parts including valve gear makes SLHC ideal for unattended operation. No hand oiling is ever necessary.

Cast-in lubricating oil manifold eliminates the necessity of any internal plumbing. Jointless and cannot leak, ever. No blind connections, screwed fittings, etc.



Six-cylinder SLHC unit installed by Northern Natural Gas Co. in the Oklahoma Panhandle.

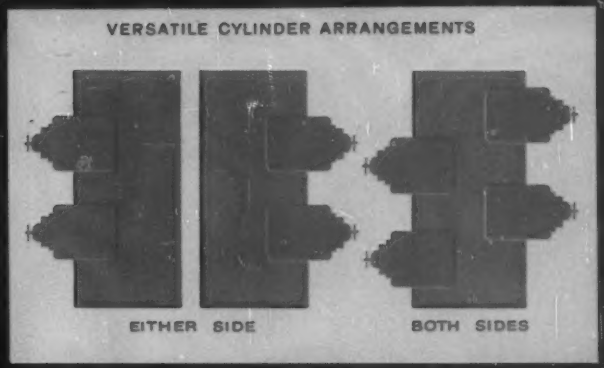


One of three 6-cylinder skid-packaged SLHC units being prepared for shipment to Bolivia, S. A.

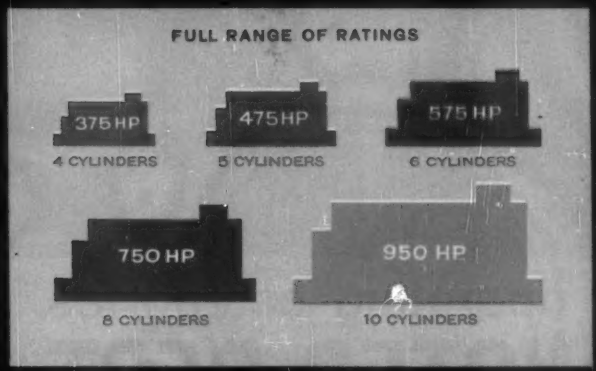
Six-cylinder skid-packaged SLHC unit for service in a Louisiana gas field.

Engine Compressor by modern, dollar-saving features

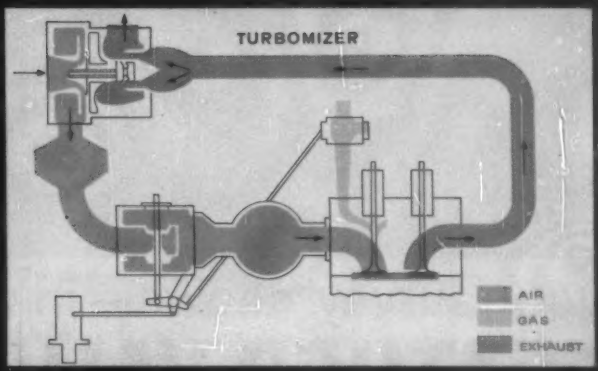
The SLHC will give you about 20% better fuel economy than currently available naturally aspirated units. This chart shows the savings per year for each 1000 hp of continuous operation on natural gas.



Piping and construction problems can be greatly simplified thanks to versatility of cylinder arrangements on SLHC. Cylinders can be mounted on either or both sides. If mounted on both sides, SLHC permits twice as many cylinders as most engine compressors in its size range.



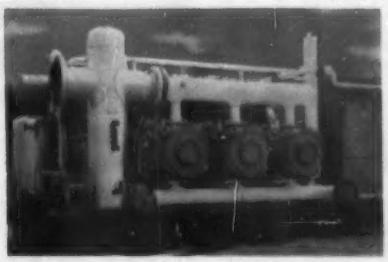
These are the range of ratings offered in the SLHC. Note that all units operate at the conservative speed of 450 rpm with a conservative bmep of under 135 psi. All units may be skid "packaged" — including the 950 hp rating, the largest available for this type service.



Worthington's Turbomizer is the simplest fuel control system on the market. It offers remarkably favorable fuel consumption and stable operation over the complete load and speed range. Allows operator to compensate for different fuels and heating values in one adjustment.

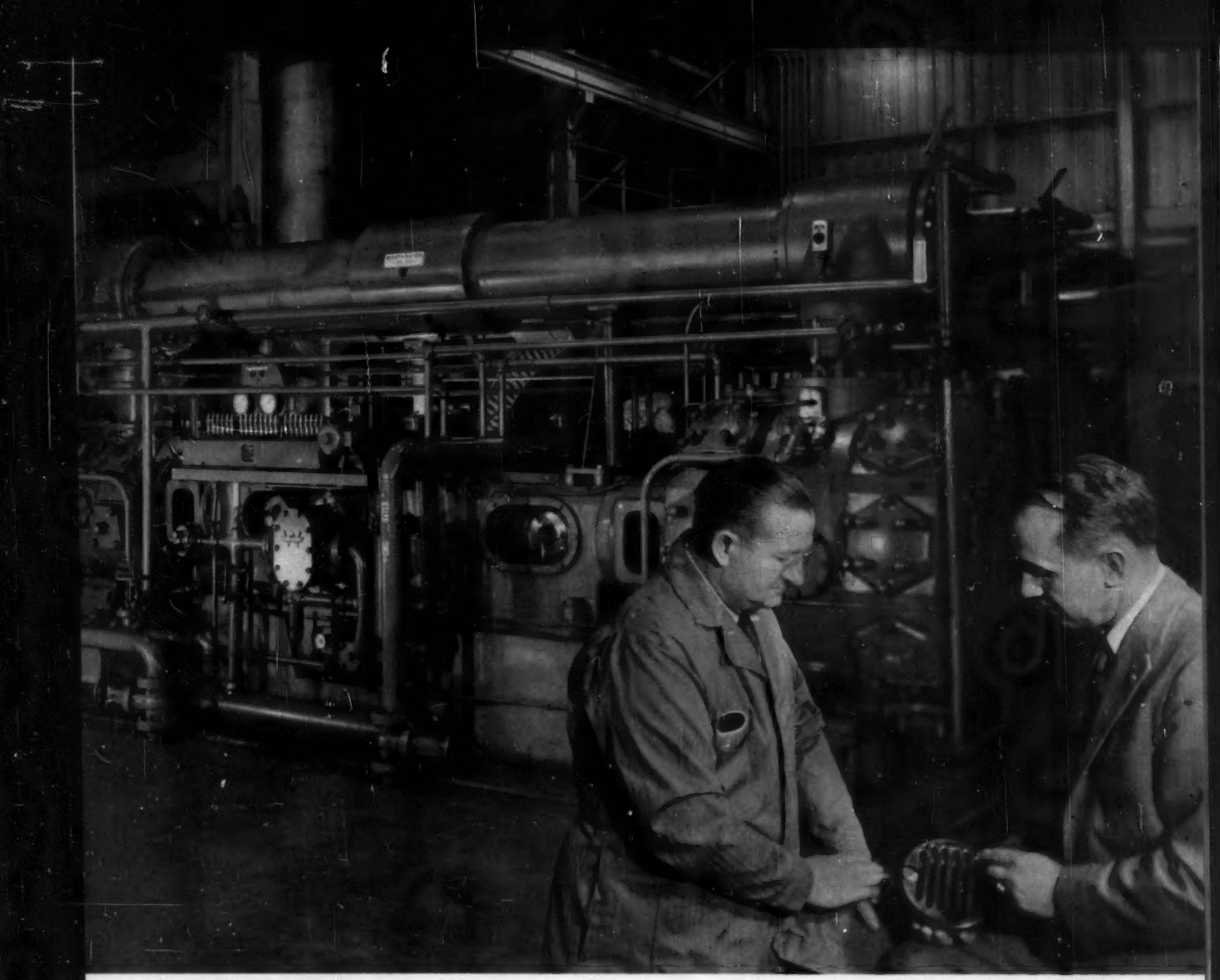
One of two 4-cylinder SLHC engine compressors to be installed by Permian Basin Pipeline Co. in Lea County, N. M.

Six-cylinder skid-packaged SLHC gas-engine compressor for a Texas natural gasoline pant.



For complete details, get in touch with your nearest Worthington district office. Or write to Worthington Corporation, Section 43-1, Harrison, N. J. In Canada: Worthington Canada Ltd., Brantford, Ont.

WORTHINGTON



User-survey shows – in all operating categories

FEATHER VALVE VOTED BEST

Simplest Construction:

FEATHER VALVE

VALVE A

VALVE B

Most Efficient:

FEATHER VALVE

VALVE A

VALVE B

Lowest Maintenance:

FEATHER VALVE

VALVE A

VALVE B

Quietest:

FEATHER VALVE

VALVE A

VALVE B

A recent survey among compressor users showed this marked preference in all four operating categories for the amazing Feather* Valve. The Worthington Feather Valve is the lightest, fastest-acting compressor valve available. Because of its lightness and flexibility it provides very sharp action with virtually no slip or back-flow. And because it works with no impact . . . has no buffer plates or cushioning devices . . . it is all but indestructible, assures long-life with negligible maintenance costs.

To get the most in performance when you buy your next compressor, specify Worthington with the rugged Feather Valve feature. Worthington Corporation, Harrison, N. J.

*REG. U.S. PAT. OFF.

WORTHINGTON

this. Court cases have a bearing on the final decision, but circumstances alter cases. For instance, you can have a business expense for entertainment which does not produce business. You take a customer to dinner and fail to close the deal. As long as this is a customary practice you can claim the expense as a deduction if it is considered "necessary."

You can be guided by two parts of the Internal Revenue Code that set up the general rules for entertainment and travel expenses:

1. The expense must be ordinary—something done frequently in your business.
2. It must be a necessary expense—one that is reasonably expected to produce business.

Must I travel in the most economical way?

No. As long as your business trip is considered ordinary and necessary, you can travel in any way you prefer. For instance, you can take a deluxe flight rather than a tourist flight, Pullman rather than chair car, or any other first class accommodations you want.

You must, however, take the most direct route or charge off the expense of any side trips for pleasure. For instance, traveling from San Francisco to New York via New Orleans would not be deductible unless you had business in New Orleans. You would be permitted to deduct only the cost of the direct trip between San Francisco and New York.

Can I deduct my wife's expenses?

This is one point Internal Revenue agents check carefully. Unless you can prove beyond a shadow of a doubt that your wife's presence is essential for business purposes, you cannot deduct her expenses on a trip. Be sure your wife is doing something business connected while on the trip if you plan to deduct her expenses.

You do get a break, however, on many travel and entertainment plans. For instance, traveling by air your wife can go for half of your first-class fare under certain conditions. Suppose that your trip costs $300 and her fare is $150. You can deduct the full $300 of your expense rather than half of the total ticket which would only be $225. The same holds true of hotel rooms that have a different rate for two than for one . . . a $10 a day room for one person and $12 for two people. You could deduct the $10 as your business expense and the $2 would be a personal expense.

What if I entertain at home?

Anyone who entertains in his home for business purposes can deduct the cost of the entertainment. This would include all food and drink and any extra help needed to handle the entertainment.

This is a touch and go proposition in proving that the entertainment was a "necessary and ordinary" business expense. Just because everyone is a potential customer of your business does not entitle you to entertain everyone and claim the expense as a tax deduction.

Continued on Page 259

for peak heat exchanger efficiency . . .

HARTZELL'S NEW CONTROLLABLE PITCH FAN

The Hartzell Controllable Pitch Fan meets a long-standing need in the petroleum industry for a precise method of controlling a variable flow of air to maintain predetermined temperatures. On test installations, these new fans have proved their ability to hold outlet temperature fluctuation to plus or minus 1½°F. And, while achieving this highly accurate level of control, they consume up to 50% less power than required by conventional fixed-pitch fans.

In a temperature sensitive control system depending on air flow, the amount of air required to achieve the necessary cooling depends on the temperature of the air. High air temperatures require high air deliveries, low air temperatures require minimum air deliveries. With a Hartzell Controllable Pitch Fan, variable air delivery is accomplished by variation in blade pitch setting. The fan assembly responds instantly and automatically to conventional temperature sensitive control equipment—increasing blade pitch to deliver more air when outlet temperature rises, decreasing blade pitch and delivering less air when outlet temperature falls.

For complete details on Hartzell's controllable pitch heat exchanger fan, write for Bulletin 111-B or call your nearby Hartzell field engineer.

HARTZELL PROPELLER FAN CO.
Division of Castle Hills Corp.
71 Thomas Blvd. Piqua, Ohio

For more data on advertised products, use Readers' Service Cards, last page.

Let Harshaw Catalysts do a GIANT'S work for you

Harshaw Catalysts do a giant's work and Harshaw produces catalysts in giant quantities—carloads every week. A letter or phone call will put our 20 years' experience and acres of production and research facilities to work for you.

PREFORMED CATALYSTS
to fit special process requirements

Hydroforming
Cyclization
Oxidation
Dehydrogenation
Dehydration
Desulphurization
Alkylation
Isomerization
Hydrogenation

Write for Free Book

CATALYTIC CHEMICALS SUPPLIED BY HARSHAW

Aluminum Nitrate — Cobalt Nitrate
Copper Nitrate — Manganese Nitrate Solution
Metallic Soaps (Cobalt, Manganese)
Nickel Carbonate — Nickel Formate — Nickel Nitrate
Nickel Sulfate — Sodium Methoxide — Zinc Nitrate

Our experienced technical staff will assist you in developing the best and most economical catalyst. If you have a catalytic process in the development or production stage, a discussion with us may prove beneficial.

THE HARSHAW CHEMICAL CO.
Chicago • Cincinnati • Cleveland • Detroit • Hastings-On-Hudson
Houston • Los Angeles • Philadelphia • Pittsburgh

TABLETS

SPHERES

EXTRUSIONS

GRANULES

POWDERS

FLAKES

For more data on advertised products, use Readers' Service Cards, last page.

How can I prove my travel and entertainment expenses?

Keep records!

Sounds simple, but most of us hate to bother with keeping records. At the end of the year, we try to reconstruct our expenses for the year. It is almost impossible. We are apt to overlook something and lose a tax deduction or include something we cannot prove and have trouble.

And, since the burden of proof is on you, it is most important that you keep detailed records of all entertainment and travel expenses to realize maximum tax deductions. Keep records.

What kind of records must I keep?

To avoid any trouble with your deduction, you will need to have rather complete records. You will need to have a record of the date of the entertainment, the people involved, the time, and details of all expenses.

You can keep this in a day-by-day record book along with your appointments. You can file a separate form each day you travel or entertain. Or, you can keep this on individual cards or forms listing all the essential information to support your income tax deductions.

Can I use my cancelled checks for supporting evidence?

Yes. But, to be in the clear you will need some detail on the check or stub or both. For instance, checks written to "cash" for round amounts such as $50 need to be supported with more details. Check stubs that say briefly "travel" are not sufficient.

Another thought you will want to consider about your cancelled checks as record keeping devices. Obviously, you do not pay all expenses of entertainment and travel by check. Thus, if you use this system altogether you will be overlooking a lot of out-of-pocket expenses (tips, for instance) that can be income tax deductions if a record is kept of them.

Can I deduct automobile expenses?

Yes. An automobile that is used only for business purposes can be handled as any other piece of equipment in your refinery. However, when there is a part-pleasure and part-business use of the automobile, this must be reported on your income tax.

The Internal Revenue Service has a worksheet (Form 2106) that helps calculate the cost of using your automobile for business. It includes information and schedules for figuring depreciation, determining the percentage of your gas, oil, service, repairs, parking, etc. that can be considered as a business expense.

You are not required to file Form 2106 with your income tax form, but you will find that it is most helpful in calculating your taxes. And, when it is submitted it makes it easy for an agent to check it in the office rather than making a call on you personally to clarify any points that are not clear.

Following these suggestions will help make your income tax reporting easier next year . . . you will have the facts to figure your tax . . . you will have the proof if necessary . . . and you will save trouble and time in reporting your tax. Also, you will save income tax dollars by taking all that you are entitled to deduct. ##

meets every requirement

the Dean Hill sulphur pump

low cost operation

heavy duty construction

reliability.

The Dean Hill vertical, molten sulphur pump equipped with a DH vertical steam turbine drive. (Available also with vertical hollow or solid shaft motor drive.)

Like all Dean Hill products, this sulphur pump incorporates all of the features to give you years of trouble-free operation. Complete steam-jacketed line shaft and discharge column assures free flow at all times. Actual liquid sulphur lubricates bearings and shaft damping bushings. The Dean Hill sulphur pump is a compact, self-contained, rigid, smooth-running mechanism capable of superior service at all times. For complete information write today, without obligation.

DEAN DH HILL PUMP COMPANY

Pump and Turbine Engineers Since 1893

Indianapolis 7, Indiana

SALES OFFICES IN PRINCIPAL CITIES.

Key TO TOP QUALITY and SERVICE

Catalog A-7
FOR COMPLETE INFORMATION

MAC-IRON

BLINDS, SPACER RINGS, TEMPORARY STRAINERS, LINE STRAINERS, and PIVOT FLANGES • • •

This comprehensive booklet is your guide to the use of specialized equipment planned and produced to function with extreme efficiency. Detailed specifications, descriptions, and data are included.

In the years of supplying to the Petro-Chemical Field MAC-IRON has developed a design and production service to a degree seldom equalled. *If confronted with an emergency or tight schedule, PHONE US.* If not in stock, the equipment you need will be made up at once.

Your inquiry will promptly bring a copy of Catalog A-7 or specific engineering data. PHONE MAin 6-3712 FOR IMMEDIATE PRODUCTION OR CONSULTATION SERVICE.

"IF YOU USE PUMPS
You need MAC-IRON Strainers"

SANDUSKY MAC-IRON OHIO
ESTABLISHED 1901
The MACK IRON WORKS COMPANY
121 WARREN ST.

If Oil Could Speak

If oil could speak it would have many fascinating truths to tell the non-oil public—truths that would win thousands of new friends for the oil industry.

But, oil can't speak—you can. You, as an individual, can win many new friends for the oil industry if you will pass the true facts on to your non-oil industry friends.

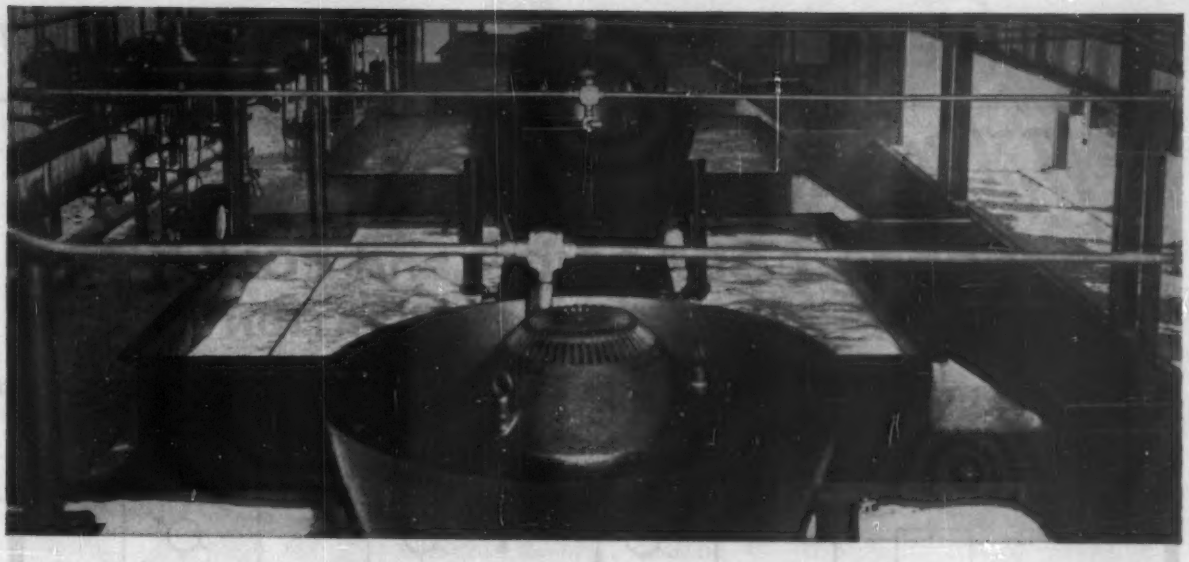
Here are some of those true facts. They are being presented for one purpose: To keep you posted on your industry, so you can tell the story oil is unable to relate.

Read these facts. You will find them informative—and interesting.

- Efficient, oil-powered diesels are saving the railroads 700 million dollars a year, according to one railroad industry spokesman.
- Swimming pools made of glass cloth-reinforced polyester resin, an oil product, can be installed in four days for less than the cost of an automobile.
- A single tankship load of gasoline would run your car for five hundred years.
- Average cost of all wells drilled below 15,000 feet runs about $617,000 per well.
- Out of 250,000 wells drilled in the U. S. during the past five years, nearly 38 percent have been dry holes. This means the production from the average well has to carry the cost of two-thirds of a dry hole in addition to its own costs.
- Out of millions of acres leased in the search for oil annually, only 5 to 10 percent prove productive.
- Although the oil industry earnings have not been out of line with earnings in other industries, the requirements for heavy reinvestment has prevented distribution of earnings to shareholders in the same proportions as other industries.

  The Department of Commerce reports that for the five years 1944-47 industrial corporations paid out in dividends about 41 percent of their net income, while larger oil companies paid out slightly more than 35 percent for the same period. In 1954, the corresponding figures were 52.9 percent for manufacturing companies and 42.7 percent for oil companies.

- Net income of other industries have averged more than the oil industry in four out of nine years (1946-54). For the 9-year average, the profits as a percent of net worth of the oil companies exceeded other industries by only one percentage point. In view of the high risks in oil production, it is not unreasonable to expect that the rate of return on the cost of succesful properties should be somewhat greater than on investments involving less risk.

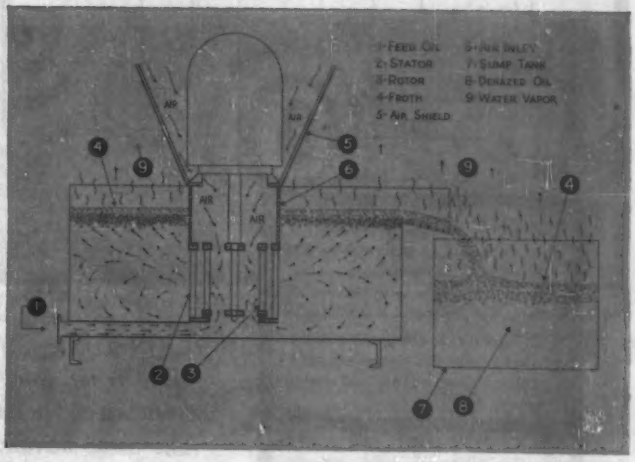


these "eggbeaters" quickly whip haze **UP-AND-OUT!**

The Hendrick Hydro-Dehazer removes haze from refinery oils quickly and economically—and without the use of compressed air, high heat, chemicals or other additives. The Hydro-Dehazer's huge rotor mixes moisture-laden oil with free air until the moisture is absorbed, rises to the top, and is discharged into the atmosphere.

Capacity is rated at 450 bph for No. 2 fuel oil at an inlet temperature of 130° with a haze point of 70° F, depending on consistency of the charge. Economy has been proven in test installations which show that Hendrick has the most efficient method—and the lowest operating cost—of all dehazers.

Hendrick will be glad to arrange a *free* demonstration. For details, mail this coupon today.



Hendrick
MANUFACTURING COMPANY
36 Dundaff Street, Carbondale, Pennsylvania
Sales Offices in Principal Cities

Perforated Metal • Perforated Metal Screens • Wedge Slot and Wedge Wire • Architectural Grilles
Mitco Open Steel Flooring • Shur-Site Treads • Armorgrids • Hendrick Hydro-Dehazer • Distillation Column Internals

HENDRICK MANUFACTURING COMPANY
36 Dundaff Street, Carbondale, Pennsylvania

Gentlemen:

I am interested in learning more about the new Hendrick Hydro-Dehazer.

☐ Please arrange demonstration of the Dehazer Pilot Model.

☐ Please send technical data.

Name_____ Title_____

Company_____

Street_____

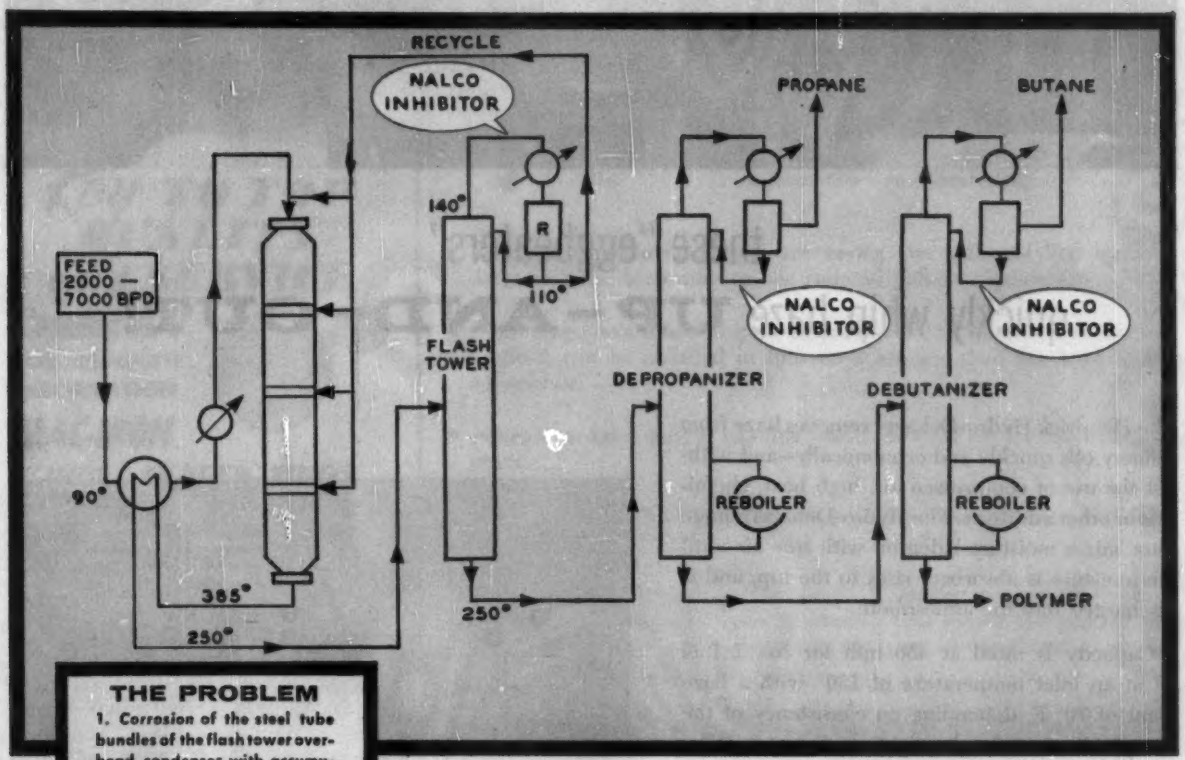
City_____ Zone_____ State_____

For more data on advertised products, use Readers' Service Cards, last page.

Nalco INHIBITORS

STOPPED CORROSION and FOULING

in this CATALYTIC POLYMERIZATION UNIT



THE PROBLEM

1. *Corrosion* of the steel tube bundles of the flash tower overhead condenser with accumulator water pH of 4.5 or below.
2. *Serious fouling* of screen trays in the depropanizer and debutanizer on normal six-month run.

THE TREATMENT

Nalco Inhibitor fed to the overhead of the flash tower, and to the reflux of the depropanizer and debutanizer towers.

THE RESULTS

1. Iron content of accumulator water reduced from .75 pounds per day to .04 pounds per day.
2. No deposits in screen trays after six-month run.

CONSIDER further the economy of dosage . . . 10 ppm to flash tower, and 10 ppm to depropanizer and debutanizer. And bear in mind that this was no isolated success story. The same advantages—less downtime, better thruput *and* effective protection for costly equipment—can be brought to your refinery by the use of Nalco Corrosion and Fouling Inhibitors. Ask your Nalco Representative or write direct.

NATIONAL ALUMINATE CORPORATION
6259 West 66th Place • Chicago 38, Illinois
Telephone: POrtsmouth 7-7240
CANADA: Alchem Limited, Burlington, Ontario
NORTHWESTERN UNITED STATES, HAWAII and ALASKA
The Flox Company, Inc., Minneapolis 3, Minnesota
ITALY: Nalco Italiana, S.p.A.
WEST GERMANY: Deutsche Nalco-Chemie GmbH
SPAIN: Nalco Espanola, S.A.

THE *Nalco*® SYSTEM . . . *Serving Industry through Practical Applied Science*

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening . . .

. . . in the Industry

Independents Key Suppliers of Crude

Domestic Refinery Runs and Crude Oil Production of Some U. S. Companies in 1957

(Data from all available annual reports of U. S. companies with refinery runs and/or crude production above 10,000 barrels daily.)

Company and Rank in Refining	Total Crude Runs To Stills		Net Domestic Crude Oil Production	
	Barrels Daily	Percent of U.S.	Barrels Daily	Percent of Runs to Stills
1. Standard Oil Co. (N.J.) (Esso Standard, Carter, & 87% of Humble)	730,015	9.22	382,687	52.4
2. Standard Oil Company (Ind.)	648,076	8.18	[1]297,980	46.0
3. The Texas Company	580,275	7.32	357,651	61.6
4. Socony Mobil Oil Company	568,227	7.18	237,125	41.7
5. Gulf Oil Corporation	536,215	6.77	306,852	57.2
6. Standard Oil Co. of California	[2]518,581	6.55	[1]299,600	57.8
7. Shell Oil Company	505,630	6.38	317,562	62.8
8. Esso Standard Oil Company	503,000	6.35	.....	....
9. Sinclair Oil Corporation	433,573	5.48	129,539	29.9
10. Cities Service Company	266,557	3.36	[1]122,271	45.9
11. Sun Oil Company	251,669	3.18	[1]121,302	48.2
12. Phillips Petroleum Company	237,753	3.01	132,007	55.5
13. Humble Oil & Refining Company	234,500	2.96	360,560	153.8
14. Tidewater Oil Company	202,527	2.56	88,848	43.9
15. Atlantic Refining Company	199,423	2.52	[1]98,110	49.2
16. Union Oil Company of California	176,148	2.23	102,575	58.2
17. Pure Oil Company	157,805	1.99	65,825	41.7
18. Continental Oil Company	147,056	1.86	133,652	90.0
19. Ashland Oil & Refining Company[3]	137,082	1.73	8,676	63.2
20. Richfield Oil Corporation	119,389	1.51	[2]57,704	48.3
21. Standard Oil Company (Ohio)	110,744	1.40	30,067	27.1
22. Sunray Mid-Continent Oil Co.	108,555	1.37	81,646	75.2
23. Skelly Oil Company	49,028	0.62	69,077	140.9
24. Ohio Oil Company	41,521	0.52	95,561	230.2
25. Plymouth Oil Company	41,101	0.52	15,150	36.9
26. Delhi-Taylor Oil Corporation	32,956	0.42	5,653	17.2
27. Tennessee Gas Transmission Co.[4]	32,877	0.42	22,657	68.9
28. Anderson-Prichard Oil Corporation	29,526	0.37	13,813	46.8
29. Monsanto Chemical (Lion Oil Company Division)	28,843	0.36	20,555	71.3
30. Clark Oil & Refining Corporation	26,628	0.34	.....	....
31. Champlin Oil & Refining Company	25,933	0.23	14,797	57.1
32. Carter Oil Company	23,000	0.29	69,000	300.0
33. Colorado Oil & Gas Corporation[5]	16,980	0.21	7,310	43.1
34. South Penn Oil Company	10,011	0.12	11,355	113.4
[6]Total 33 Companies	7,001,207	88.41	[7]4,222,263	[7]60.3
Remainder of Industry	917,795	11.59	2,952,761	321.7
Total United States	7,919,002	100.00	7,175,024	90.6

See end of article for references.

INDEPENDENT operators and small producing companies of the U. S. are vitally needed by refiners as sources of crude oil. In 1957 the independents supplied 3 out of every 8 barrels of the crude oil run to stills at U. S. plants.

Because of the heavy requirements of major and independent refiners for independently produced crude, the smaller producers have continued to enjoy steady demand for their oil, at good prices. The demand has decreased during the past year of business recession. But to the extent of that reduced demand, crude production has found reasonably firm markets.

This interdependence of producers and refiners upon each other is made evident by the tabulation herewith.

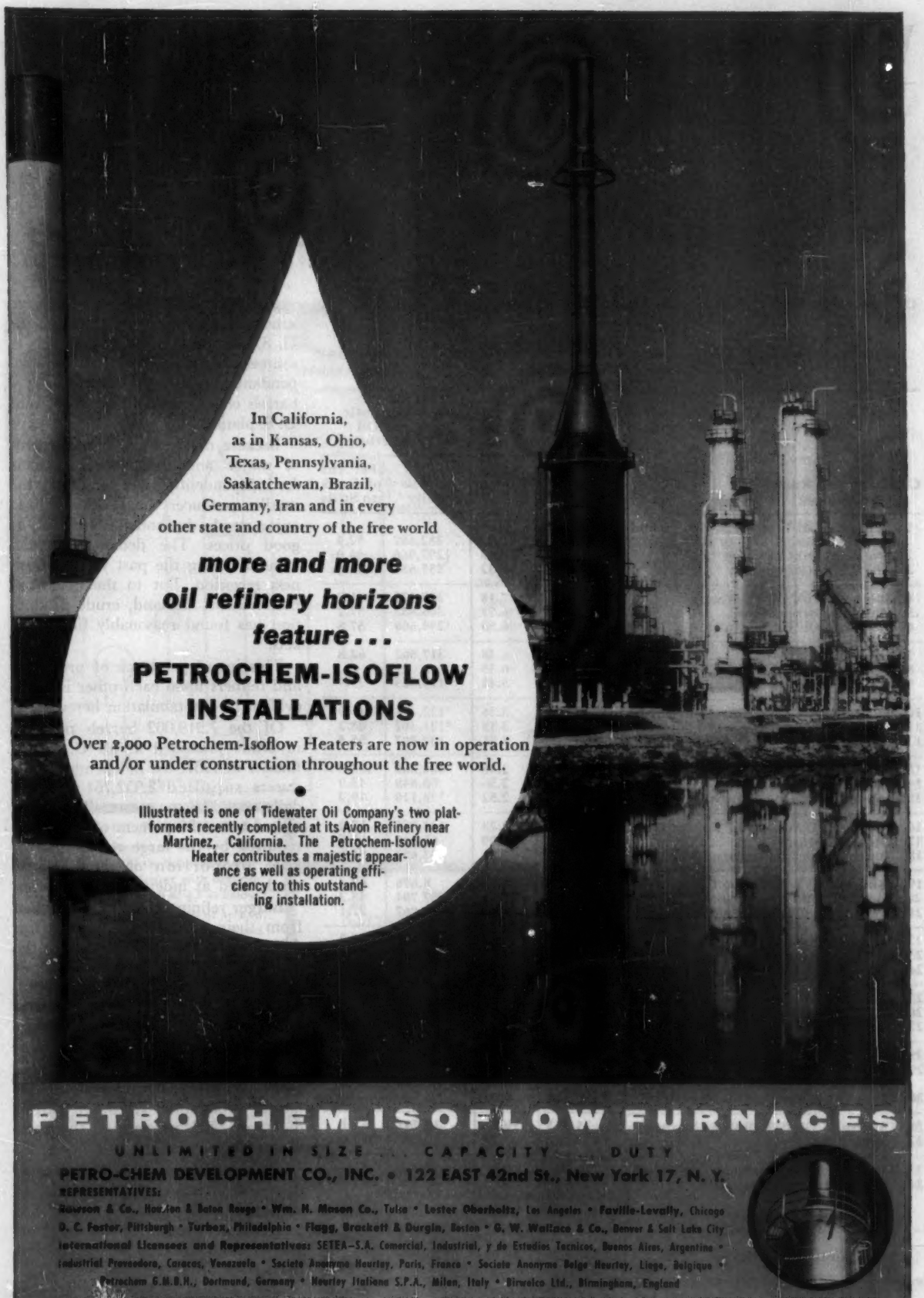
Of the 7,919,002 barrels per day of crude processed at all U. S. refineries in 1957, the independent producers supplied 2,952,761 barrels daily, or 37.3 percent. They furnished about 29 percent of the crude required by the large refiners and a large proportion of the domestic crude used at independent refineries.

Larger refining companies supplied from their own gross production 4,222,263 barrels daily, including the operator's 7/8 and the land owner's 1/8 of each gross barrel produced. That was 53.3 percent of the total U. S. runs and 60.3 percent of the large companies' own refinery runs.

The independents and large companies together supplied from domestic production 7,175,024 barrels daily, or 90.6 percent of the total crude processed.

The remainder of 743,978 barrels daily or 9.4 percent of crude run to stills at U. S. plants in 1957 was supplied principally by an 860,000-barrel-per-day excess of crude imports over crude exports.

(In addition to supplying refinery



In California,
as in Kansas, Ohio,
Texas, Pennsylvania,
Saskatchewan, Brazil,
Germany, Iran and in every
other state and country of the free world

more and more
oil refinery horizons
feature . . .

PETROCHEM-ISOFLOW
INSTALLATIONS

Over 2,000 Petrochem-Isoflow Heaters are now in operation and/or under construction throughout the free world.

●

Illustrated is one of Tidewater Oil Company's two platformers recently completed at its Avon Refinery near Martinez, California. The Petrochem-Isoflow Heater contributes a majestic appearance as well as operating efficiency to this outstanding installation.

PETROCHEM-ISOFLOW FURNACES

UNLIMITED IN SIZE . . . CAPACITY . . . DUTY

PETRO-CHEM DEVELOPMENT CO., INC. • 122 EAST 42nd St., New York 17, N. Y.

REPRESENTATIVES:

Dawson & Co., Houston & Baton Rouge • Wm. H. Mason Co., Tulsa • Lester Oberholtz, Los Angeles • Faville-Levally, Chicago
D. C. Foster, Pittsburgh • Turbex, Philadelphia • Flagg, Brackett & Durgin, Boston • G. W. Wallace & Co., Denver & Salt Lake City
International Licensees and Representatives: SETEA–S.A. Comercial, Industrial, y de Estudios Tecnicos, Buenos Aires, Argentina •
Industrial Proveedora, Caracas, Venezuela • Societe Anonyme Heurtey, Paris, France • Societe Anonyme Belge Heurtey, Liege, Belgique •
Petrochem G.M.B.H., Dortmund, Germany • Heurtey Italiana S.P.A., Milan, Italy • Birwelco Ltd., Birmingham, England

requirements, U. S. crude production and the net crude imports covered normal transfers of crude to fuel oil stocks, crude used as fuel, losses, and limited net additions of domestic and foreign crude to storage.)

Most of the major companies depend heavily upon independent producers for crude supply. In most instances, the large company's own net domestic production of crude represents only 40 to 60 percent of its total domestic crude runs to stills. (See Table.)

[1] Includes natural gas liquids. [2] Western Hemisphere. [3] Data for 12 months ended Sept. 30, 1957. [4] Refining is by wholly-owned subsidiary, Bay Petroleum Corp., at Denver and New Orleans. [5] Refining is by wholly owned subsidiary, Derby Ref. Co., at Wichita, Kans. [6] Total excludes Standard (N.J.), whose U.S. affiliates, Carter, Esso Standard, and Humble, are included. [7] Includes the 3,694,480 barrels daily net production of above companies and an estimated 527,783 barrels daily of royalty and co-owner oil produced by those companies. [Also see Footnote 6.

Sinclair First in 1957 Safety Contest

Refinery	Rank	Frequency
Sinclair Refining, Marcus Hook, Pa.	1	0.31
Standard Oil Co. (Ind.), Whiting Refinery	2	1.26
Esso Standard Oil, Baton Rouge Refinery	3	1.29
Esso Standard Oil, Bayonne Refinery	4	1.62
Sinclair Refining, Houston, Texas	5	1.68
Humble Oil & Refining, Baytown Refinery	6	1.73
Socony Mobil Oil Co., Paulsboro Refinery	7	1.76
The Atlantic Refining, Philadelphia Refinery	8	1.97
American Oil Co., Texas City Refinery	9	2.02
The Texas Company, Port Arthur Works	10	2.06
Esso Standard Oil, Bayway Refinery	11	2.24
Sinclair Refinery, East Chicago, Ind.	12	2.44
Standard Oil (Ind.), Wood River Refinery	13	2.98
Shell Oil Co., Wood River Refinery	14	3.07
Shell Oil Co., Houston Refinery	15	4.07
Cities Service, Lake Charles Refinery	16	4.73
DX Sunray Oil Co., West Tulsa Refinery	17	5.71
Creole Petroleum, Amuay Refinery	18	5.76

The National Safety Council has announced that Sinclair Refining Co.'s Marcus Hook, Penn., refinery finished in first place in its category of the 1957 Petroleum Section Safety Contest.

The final bulletin for the contest shows that Marcus Hook refinery placed first among 18 refineries where employes work more than 250,000 man-hours a month. Marcus Hook's frequency rate was 0.31 for 1957. The frequency rate is computed by multiplying the number of disabling injuries by 1 million, then dividing by the number of man-hours worked.

Taking second place among the 18 refineries in the large refinery category was The Standard Oil Co. (Ind.) refinery at Whiting, Ind., with a frequency rate of 1.26. Esso Standard Oil Co.'s Baton Rouge refinery was third with a frequency rate of 1.29, the second best rate in the refinery's history.

In the competition for entire company operations, Lago Oil and Transport Co. (Aruba) finished in first place with a rate of 0.61.

Above is a tabulation of all 18 participants.

Gas Standards Are Up According to Ethyl Survey

Ethyl has offered materials to help industry answer complaints of consumers who think the price of gasoline is too high. The promotion, "New Concept of Gasoline Progress", is based on a survey showing a comparison of today's gasoline value on a ton-mile basis (distance one

ASME Code
National Board Inspection
Pressure Vessel
Fabrication
Carbon Steel
Alloys
Alloy Clad
ROLLING CAPACITY
4" thick

BROCHURES WILL BE MAILED UPON REQUEST

GENERAL
WELDING WORKS, INC., HOUSTON
P. O. BOX 10197
HOUSTON 18, TEXAS
UNderwood 9-1458

Here's proof

Superior quality forged body —precision machined
Uniform wall thickness —no weak spots
Extra heavy reinforcing rim
Larger diameter cam ears for longer service life
Extra Hi-Strength forged handles —greater economy
Stainless Steel pins —greater safety and longer service
Uniform heavy wall thickness —no weak spots
Recess retains gasket in coupler and assures proper placement
Superior quality forged body —precision machined —accurate tolerances

your best buy is EVER-TITE -the best quality quick couplings

Bronze
Aluminum
Stainless
Carbon
Malleable
Hastelloy

You save time and money when you use EVER-TITE COUPLINGS, because you get speedy deliveries—no leaks.

The tightness is predetermined in manufacture so you can be *sure* with EVER-TITE.

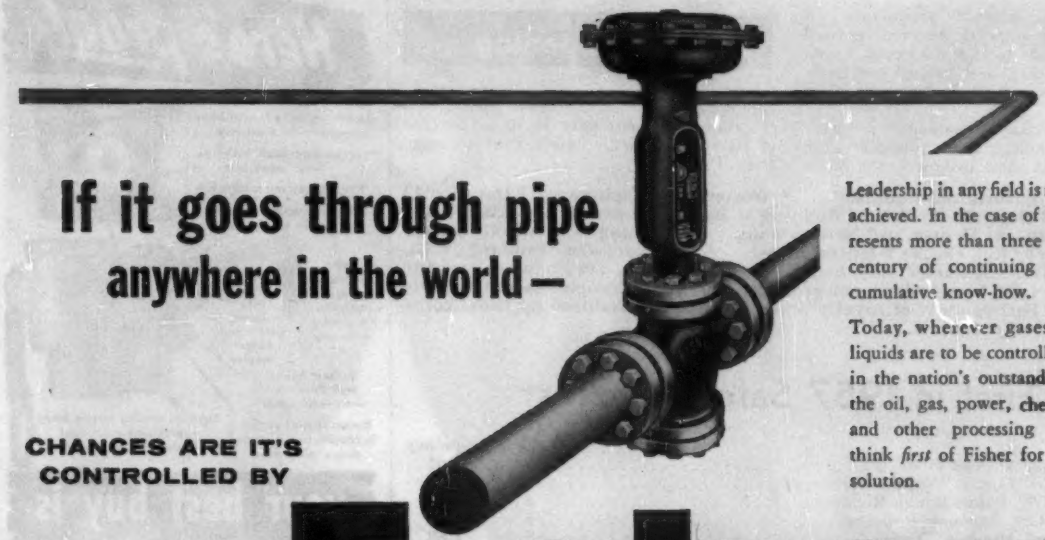
The EVER-TITE trademark is a hallmark of dependability. EVER-TITES do the best job in the transfer of every type of product through hose or pipe.

Get EVER-TITE and get the *best*. Ask your distributor now.

EVER-TITE COUPLING CO. INC.
254 West 54th Street
New York 19, N. Y.

Every EVER-TITE saves time and money

For more data on advertised products, use Readers' Service Cards, last page.



If it goes through pipe anywhere in the world—

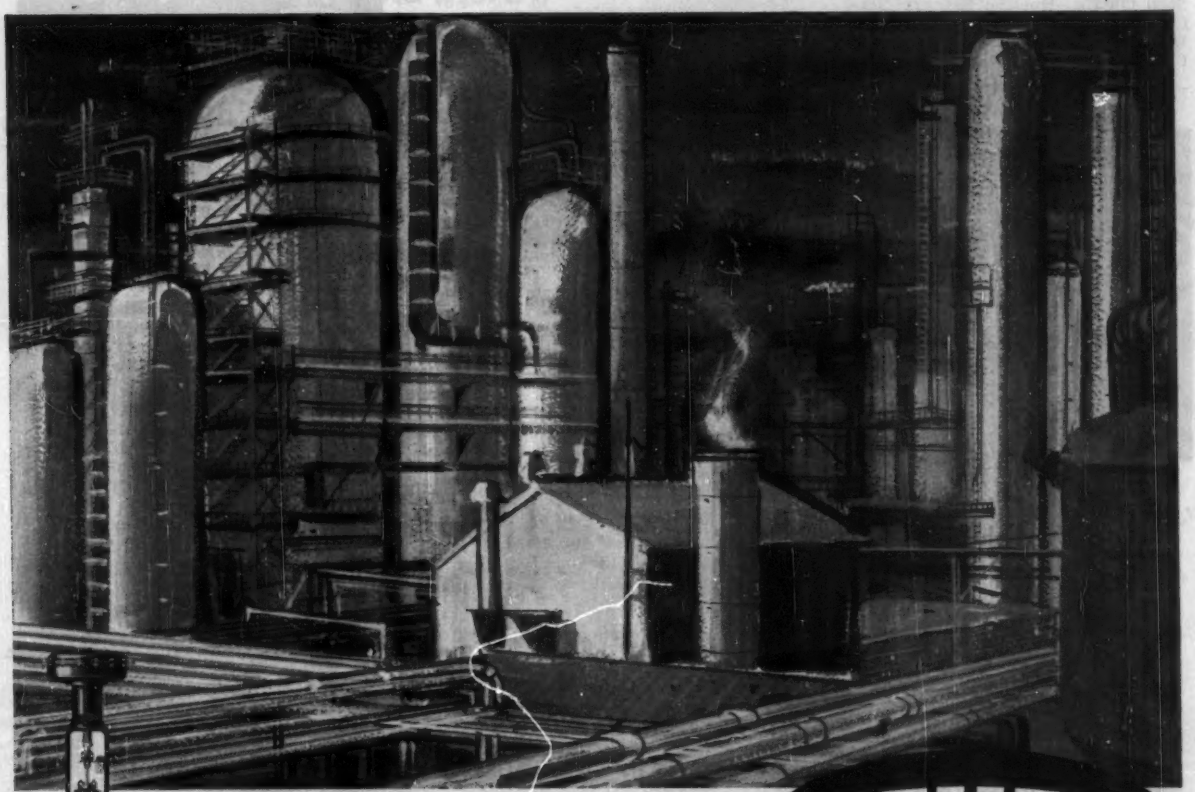
CHANCES ARE IT'S CONTROLLED BY

Leadership in any field is never casually achieved. In the case of Fisher it represents more than three quarters of a century of continuing research and cumulative know-how.

Today, wherever gases, steam and liquids are to be controlled, engineers in the nation's outstanding plants in the oil, gas, power, chemical, paper and other processing industries... think *first* of Fisher for the maximal solution.

Fisher

Manufacturers of: PRESSURE REGULATORS, DIAPHRAGM MOTOR VALVES and LIQUID LEVEL CONTROLLERS



Engineers with special problems... find the answer in...

FISHER® Controls

SINCE 1880

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England

CONTINENTAL EQUIPMENT CO. DIVISION, Coraopolis, Pennsylvania

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening. . .

gallon of gas will move one ton of car) with the value of gasoline sold in 1930.

According to the survey, gasoline today does 70 percent more work at 18 percent lower cost than it did in 1930. Gasoline cost per ton-mile in 1930 was $.066, while in 1957 it is $.054. The survey revealed that the comparison is favorable even when taxes are included.

Shell Removes Dependents From Borneo Refinery

Shell Oil Co. has sent a ship to Balikpapen, Indonesian Borneo, to evacuate dependents of about 100 foreign employes at the refinery and Borneo fields. The action came as the result of refusal to let tankers enter port.

The Borneo refinery has been closed for an indefinite period because of the April 28 bombing and sinking of the chartered tanker San Flaviano in Balikpapen harbor by rebel aircraft based on Menado Island in Celebes.

Half of the 50,000-bpd refinery's products go to the Indonesian domestic market, and the other half is exported. Shell reported that it will be able to meet the export demand from Abadan and Bombay, and will meet its 70 percent share of the Indonesian market by increasing manufacturing at Pladju refinery in South America.

Tidewater Ad's Challenge Industry to Octane Race

"We've got more octane potential than anyone else and we're going to make the most of it." This is the statement Tidewater Oil Co. made to the oil industry recently in challenging it to an octane race in advertisements in 250 Eastern daily newspapers.

J. G. Jiminez, general manager of the company's eastern division said, "We may be upsetting a few applecarts, but that's competition. We've waited a long time to take off our gloves in an out-and-out octane race, but we didn't ask anyone's permission to build our Delaware refinery, and we aren't asking anyone's permission to get on top and stay there in the battle for octane."

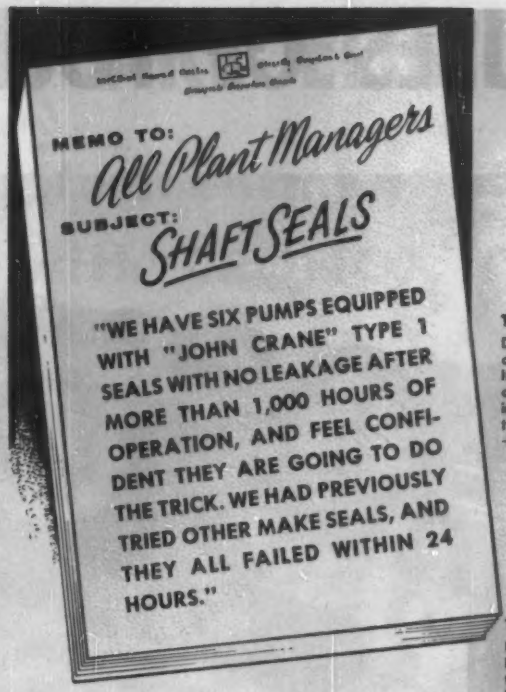
New AGIP Facilities

AGIP, the Italian State owned oil agency, is building a mile long concrete terminal at the port city of Gela, Sicily, to accommodate tankers up to 18,000 dwt.

A nearby refinery is under construction to extract bitumen from crude oil. The plant is expected to go on stream in July. The increase in facilities is in anticipation of higher production from the area because of five new wells now drilling. AGIP has four producing wells in the area.

Use of Power Fuels Shown

Power plants consumed 6,442,389 barrels of fuel oil during February, a drop of 7.5 percent from the 6,962,552 barrels used in the same month last year, according to the Federal Power Commission. Also revealed in the report: Coal consumption amounted to 13,572,409 tons,


MEMO TO:
All Plant Managers
SUBJECT:
SHAFT SEALS
"WE HAVE SIX PUMPS EQUIPPED WITH "JOHN CRANE" TYPE 1 SEALS WITH NO LEAKAGE AFTER MORE THAN 1,000 HOURS OF OPERATION, AND FEEL CONFIDENT THEY ARE GOING TO DO THE TRICK. WE HAD PREVIOUSLY TRIED OTHER MAKE SEALS, AND THEY ALL FAILED WITHIN 24 HOURS."

This is part of an actual memo sent by one plant manager to others of the same company in different sections of the country—and that company is now exclusively specifying these and other type "John Crane" Shaft Seals for *all* their liquid handling requirements.

You too can save time, trouble and expense by doing likewise.

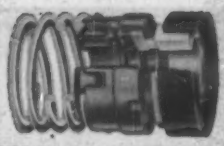
You'll find a "John Crane" Shaft Seal for every service . . . from hot or cold water to the most destructive acids and corrosives . . . high temperatures, high pressures . . . in types and sizes to meet practically any mechanical or dimensional requirement.

Send us details on your application. We'll recommend the proper shaft seal. Request Bulletin S-204-3 for complete overall information.

Crane Packing Co., 6420 Oakton St., Morton Grove, Illinois, (Chicago Suburb).

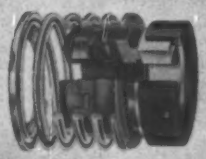
In Canada: Crane Packing Company, Ltd., Hamilton, Ont.

John Crane®



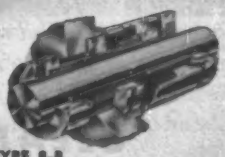
TYPE 1

Designed for limited stuffing box diameter. Handles water, light hydrocarbons, refrigerants, mild acids and other liquids noninjurious to synthetic rubber at temperatures from −40°F. to +212°F., pressures to 200 psi.



TYPE 2

Designed for limited stuffing box length. Handles same services, temperatures and pressures as Type 1.

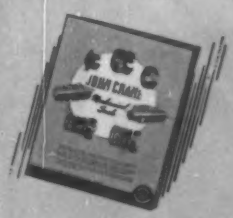


TYPE 8-B

Heavy duty, high pressures. Packaged construction for easy installation. Handles pressures to 1200 psi., temperatures from −40°F. to +250°F. Services same as Type 1.

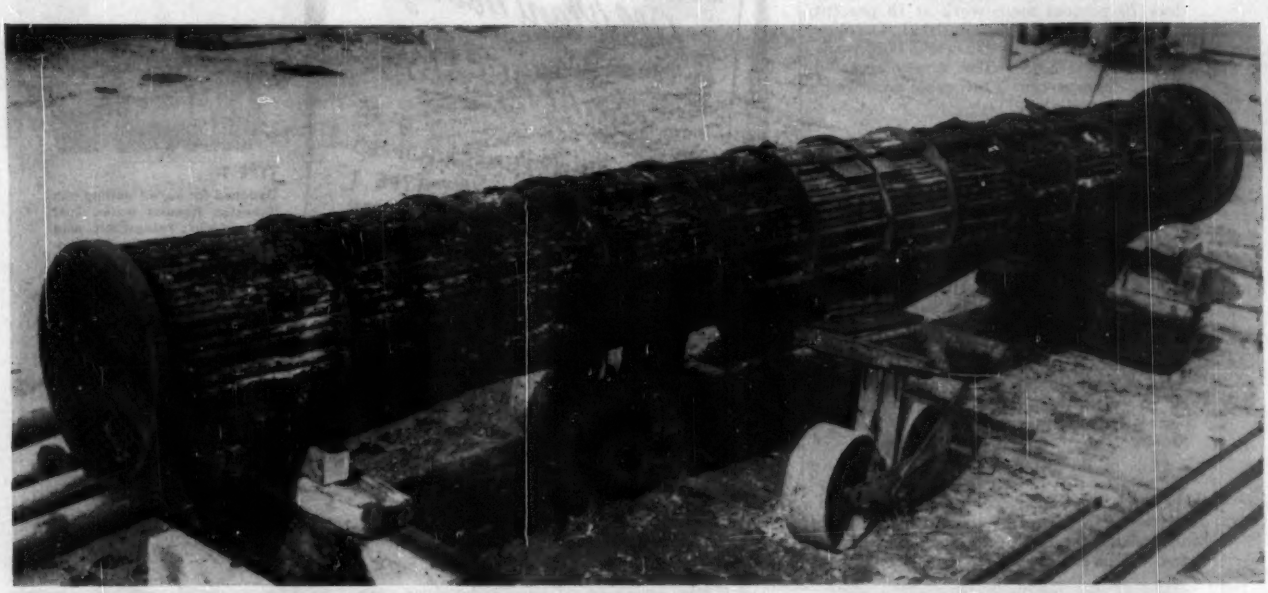
TYPE 9

Famous as a problem solver. Sealing members of chemically inert Du Pont Teflon. Engineered to service conditions to handle practically all destructive acids, corrosives and gases at temperatures from −120°F. to +500°F., pressures to 150 psi. Available in balanced construction for pressures to 750 psi.



For more data on advertised products, use Readers' Service Cards, last page.

CAUSES OF FOULING AND



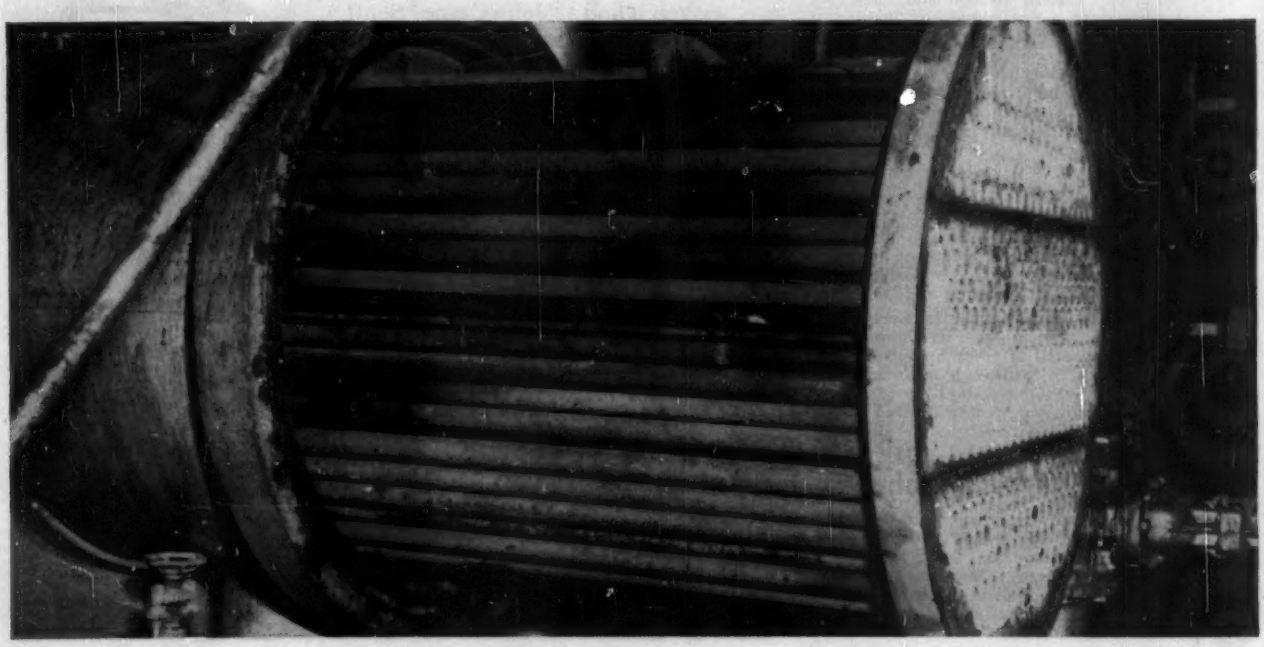
CLEAN . . .
AFTER TWICE THE SERVICE

▲

After 9 months, processing 1 million barrels of naphthenic coastal crude, gasoline cooler bundle is severely fouled and corroded, requiring extensive cleaning and re-tubing.

After 18 months, processing 2 million barrels of same crude—but with CRONOX C treatment used continuously—bundle is clean, needs only hosing before returning to service.

▼



For more data on advertised products, use Readers' Service Cards, last page.

CORROSION ARE ELIMINATED

. . . by simple treatment of crude with CRONOX® C

Refineries can enjoy important savings in the operation and maintenance of crude units by using the CRONOX C conditioning treatment, which actually *removes* corrosive and fouling agents from crude oil.

Longer periods on stream. In typical refineries where CRONOX C treatment is in regular use, time between turnarounds has been doubled, increasing annual throughput by many days. Turnarounds are scheduled less frequently, are shorter and less costly.

Increased equipment life. Within the crude unit, preheat and bottoms exchangers, crude heaters, towers and overhead equipment not only last months, even years longer, but all perform more efficiently because they stay clean.

CRONOX C conditioning solution chemically treats the desalted feed-stock two ways. First, it removes oxygen from the crude, thus retarding corrosion by hydrogen sulfide and preventing the formation of fouling gums, scale and coke. Second, it neutralizes hydrochloric and naphthenic acids, rendering these agents harmless. CRONOX C conditioning solution and the reaction products formed have no effect upon products or catalysts.

Simple to use. CRONOX C treatment is not an extra process, needs no extensive control. Simply inject CRONOX C conditioning solution into the suction of the crude charge pump. The chemical injection system is a simple arrangement of equipment you probably have on hand.

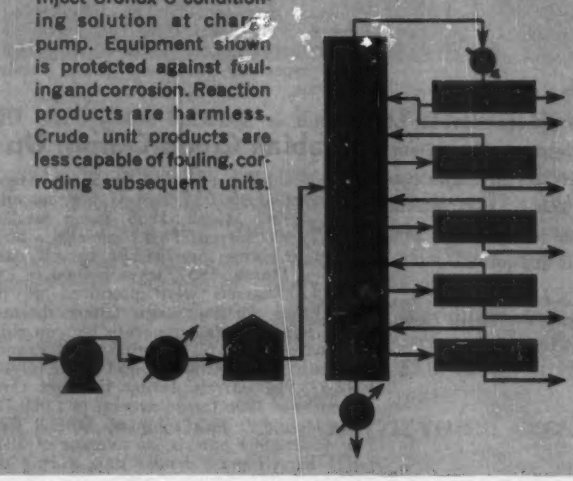
For complete data, send us the coupon below.

ATLAS

Aquaness Department

ATLAS POWDER COMPANY

2005 Quitman Street, Houston 26, Texas



Inject Cronox C conditioning solution at charge pump. Equipment shown is protected against fouling and corrosion. Reaction products are harmless. Crude unit products are less capable of fouling, corroding subsequent units.

Aquaness Department, Atlas Powder Co.
2005 Quitman Street, Houston 26, Texas

_____ Please send me a copy of the new Booklet on Cronox C.

_____ Please have a representative call.

NAME _____

COMPANY _____

STREET _____

CITY _____ ZONE _____ STATE _____

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening . . .

2.8 percent above the 13,208,117 tons used in February, 1957.

Gas consumption amounted to 75,558,574 MMcf, a decreate of 9.2 percent from 83,243,775 MMcf burned in February, 1957.

Fuel oil stocks on hand as of March 1 totaled 19,515,448 barrels, compared with 20,018,980 barrels a month earlier and 15,955,535 barrels a year before. Oil stocks, based on February use, were sufficient for 85 days' requirements compared to 86 days a month before and 64 days a year ago.

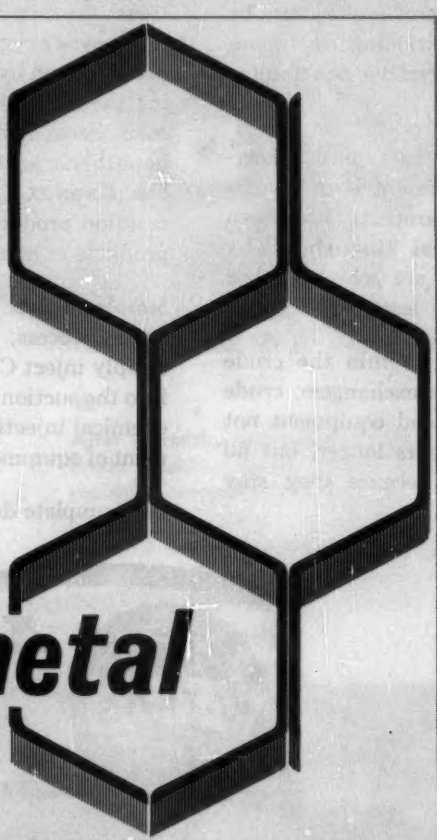
Conservationists, Oil Men Meet With Secretary Seaton

Secretary of the Interior Seaton held a meeting recently with eight conservationists and eight oil men to determine how the oil industry can make a more significant contribution to the nation's conservation movement.

One Interior Department source said the meeting was in the nature of an informal "get-together", and that another will be held in a few months. He added, "The oil industry, apart from leasing on wildlife lands, has a big stake in the whole field of conservation in this country. We feel they will be able to make a real contribution to a matter that concerns every American."

HOW MANY YEARS WILL A GOOD LINING LAST?

Make it with Hexmetal



AND DOUBLE THE NUMBER YOU FIRST THOUGHT OF

A lining lasts as long as its bonding properties.

The natural organic bond of refractory clays and the chemical set of concrete all fail eventually under the stresses imposed upon them. When a lining is "bonded" or given "bone" by Hexmetal Reinforcement, it holds in position long after all its natural bond is burnt out by heat or chemical action. The independent pinned joint of Hexmetal cells give twice the life of other reinforcements with lug joints.

Industry is year by year proving the value of these claims in Flues, Ash-Pits, Reactors, Cyclones, Cat Crackers, Coke Hoppers, Down Comer Pipes, Hydroformers, Water Turbine Flumes, Underground Galleries, etc.

Write or telephone for fullest details.

CAUSEWAY REINFORCEMENT LIMITED
66 Victoria Street, London, S.W.1 England (Victoria 8648)
CABLES: Hexmetal, London.

Alberta Sands Look Good

The Research Council of Alberta told the Borden Commission recently that recoverable reserves in the Athabasca tar sands area are estimated at 23-million barrels, compared with Canada's 30-billion barrels in ordinary reserves.

Out of the tar sands total, the council reported, only about 3-million barrels promise to be competitive with other Alberta crude in the near future. The other 20-million barrels would require subsurface recovery, with economic competition depending on technical advances.

The council added, "It now appears that Athabasca oil is a little further away from being competitive because of sharply rising plant construction costs. Nevertheless, it appears that the first billion barrels of Athabasca oil will enter the crude market before too long, and development of 2-million barrels available under more severe overburden conditions should follow fairly closely."

Upswing Coming Soon Says Noted Economist

Dr. O. Glenn Saxon, Yale University economist, recently told the Connecticut Petroleum Association that the recession has hit bottom and recovery will begin in the third and fourth quarters of 1958. Full recovery will come in the first and second quarter of 1959, "with 1960 starting a new decade of prosperity, barring war and a new spiral of prices," he said. Spiraling inflation cuts the value of the dollar in half every 18 years, and eventually could lead to a depression worse than that in the 1930's, he added.

Saxon said the spiral can be halted by (1) breaking the labor monopoly, which has received wage increases out of proportion to productivity increases, and (2) by cutting prices through a slash in federal wartime excise and income taxes.

New Method for Detecting Porphyrin Content in Crude

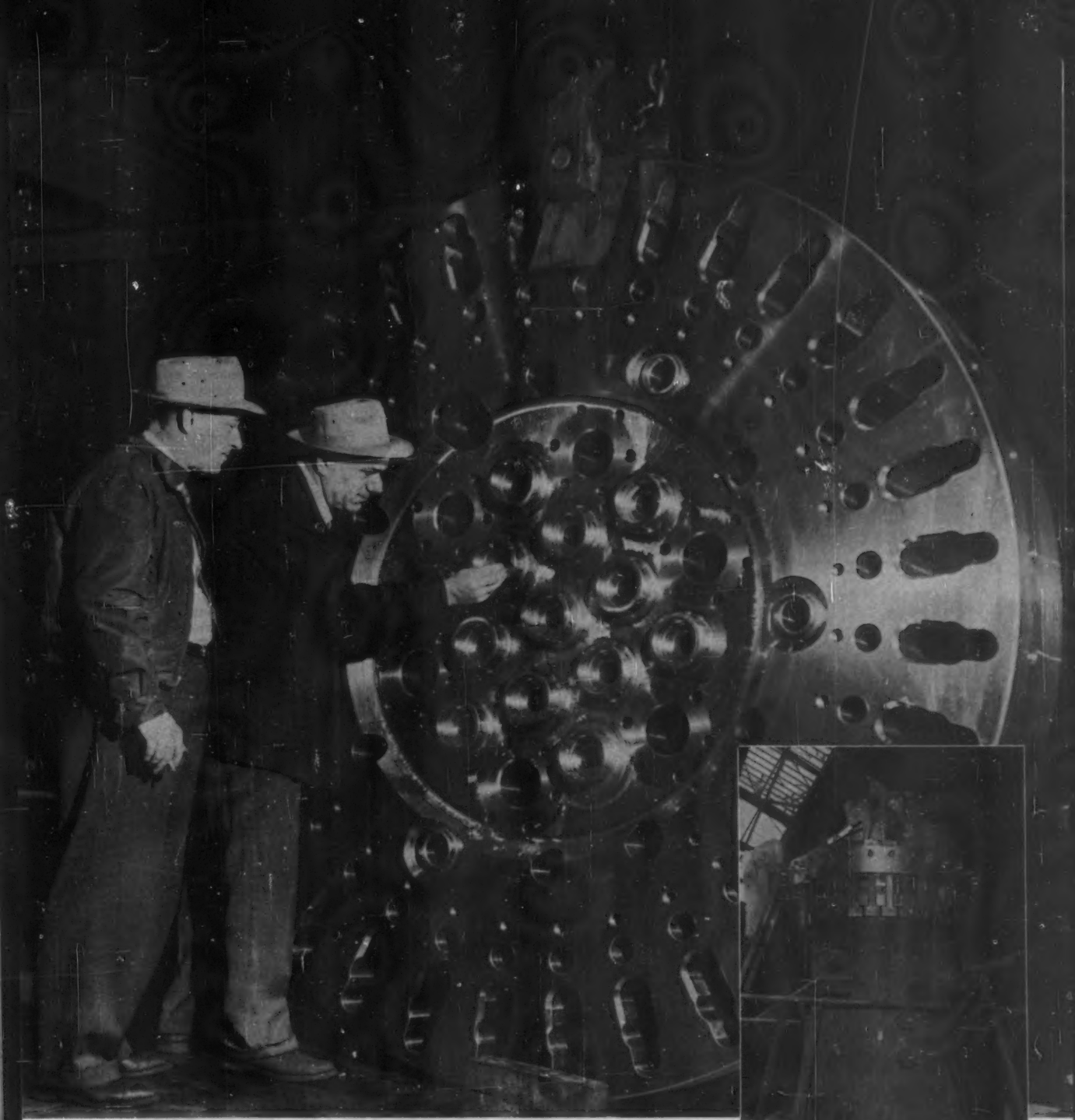
A new method for detecting porphyrins was described at a recent meeting of the American Chemical Society by Dr. John Sanik, Jr., research scientist for Standard Oil Co. (Ind.) laboratories.

With his techniques, only hours instead of days are required to measure the porphyrins in crude oil. The difficulty with porphyrins results from their combining with metals. These porphyrin compounds are especially troublesome as catalyst poisons.

Arabian Crude Output Up

Crude oil production in Saudi Arabia averaged 1,050,954 barrels per calendar day during March, 1958, for a total of 32,579,568 barrels. This represents a large increase above the 784,691 barrels daily during March, 1957, when a total of 24,325,430 barrels were produced at the height of the Suez crisis tanker shortage and King Saud's temporary ban on shipments of Saudi oil to Britain and France. Aramco's total production of crude oil was 92,673,954 barrels during the first three months of 1958 for an average of 1,029,711 barrels daily. This compares with a total of 65,242,901 barrels, an average of 724,921 barrels per calendar day, during the

For more data on advertised products, use Readers' Service Cards, last page.



This pressure vessel had to be designed with a closure that would open in 30 minutes, and withstand 1500 psi, 550F. Made of Type 304 stainless, the top head has 34 connections, of which 19 required exceptionally close tolerances for control rods.

FOR NUCLEAR NEEDS of Knolls Atomic Power Laboratory, M. W. Kellogg was given the exacting assignment of designing and producing a 32½-ton "Proof Test Reactor Pressure Vessel". This was an unusually complex task, because of the quick-opening closure specifications, requiring a head with novel design and extremely close tolerance machining.

FOR NUCLEAR NEEDS of others, Kellogg is supplying the primary coolant stainless piping for two nuclear plants. In addition, Kellogg is equipped to engineer and manufacture heat exchanger equipment for nuclear energy power plants. If these specialized skills suggest a solution to *your* nuclear problems, call Kellogg's Fabricated Products Sales Division.

THE M. W. KELLOGG COMPANY, 711 THIRD AVENUE, NEW YORK 17.

A SUBSIDIARY OF PULLMAN INCORPORATED

The Canadian Kellogg Company Limited, Toronto • Kellogg International Corp., London • Kellogg Pan American Corp., New York
Societe Kellogg, Paris • Companhia Kellogg Brasileira, Rio de Janeiro • Compania Kellogg de Venezuela, Caracas

M KELLOGG W

same period last year.

Crude runs at the Ras Tanura Refinery amounted to 6,702,570 barrels in March, 1958, for an average of 216,212 barrels per calendar day, as compared with 6,692,854 barrels or an average of 215,899 barrels per calendar day during March, 1957. During the first three months of 1958, Aramco charged 17,565,654 barrels at Ras Tanura for an average of 195,174 barrels per calendar day. This compares with 19,068,030 barrels, an average of 211,867 barrels per calendar day during the first three months of 1957.

MPSA Sees Jet Fuel Climb

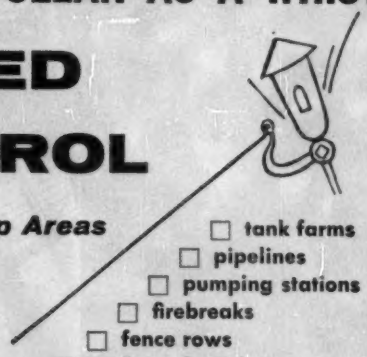
The military will be using 50 percent more jet fuel than it used in 1957 by 1963, according to Rear Adm. O. P. Lattu, executive director of the Military Petroleum Supply Agency. Lattu predicted a rapid growth in use of JP-5, adding that of the total jet fuel used by the military in 1963, 96 percent will be JP-4.

For aviation gasoline, peak requirements will come in 1959. After that, the use of AVGAS will decline at a rate of about 11 percent a year, Lattu said. He added that military use of motor gasoline and diesel will drop gradually between now and 1963, but Navy Special and other products will remain essentially constant.

NOW! Get CLEAN-AS-A-WHISTLE

WEED CONTROL

In Non-Crop Areas



- ☐ tank farms
- ☐ pipelines
- ☐ pumping stations
- ☐ firebreaks
- ☐ fence rows
- ☐ paths and roads
- ☐ drainage ditches

with amazing new **UROX®** WEED KILLER

Longer lasting! Saves time and money! Now you can control troublesome vegetation *for a longer time and at lower cost* than ever before—with UROX, General Chemical's sensational new weed killer.

You need only one application a year under normal growing conditions! Small quantities do the job! And results "carry over"! Light "booster" doses keep most areas weed-free from season to season. Easy to use, too!

Write for complete information

Allied Chemical

GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N. Y.

WPRA Student Program Planned for Regionals

The Board of Directors of the WPRA, at their recent annual meeting, approved a Student Participation Program for all regional meetings. This program sets forth the mechanism by which papers, by students from recognized colleges and universities, may be presented at a WPRA technical meeting. Students, graduate or undergraduate, with concurrence of their academic supervisor, will be invited to present papers on petroleum refining, or related subjects, at regional meetings of the WPRA. The student may have accepted employment prior to the meeting date, which would in no way negate his participation.

The student's expenses, incurred in travel to this meeting, will be paid by the association. The paper, as presented, will be published and distributed to association members. The student should address a letter of intent to the Technical Director, WPRA, 1428 Hunt Building, Tulsa, Okla., stating briefly: (a) The name of the college official concurring or sponsoring his action; (b) Title and synopsis of the subject covered; (c) Name of author or authors.

Upon receipt of the letter of intent the Regional Program Committee of the WPRA will evaluate the proposal and issue an invitation to the author.

SBA Explains New Small Refiner Rules

Small Business Administrator Barnes has elaborated on reasons for a new definition of the small petroleum refiner.

Barnes said, "I have taken into consideration the difference in the number of employes of a company according to its operation and, based on the testimony offered, find that the 500-employe limitation, as proposed, would eliminate some small refineries from participating in the set-aside program because of their marketing activities. To prevent this I have determined that 1,000 employes would allow such small refineries to participate."

Barnes explained why SBA will use the capacity rather than the "throughput" as one of the criteria for certification, required for selling petroleum to the government. Barnes said "throughput" would vary from month to month. He added that capacity is the proper method for determining the capabilities of a petroleum refining firm.

Ethyl Discharges 449

Ethyl Corp. has reduced the work force at its tetraethyl lead plant, Baton Rouge, La., by 449 employes. The company has attributed the action to "excessive inventories" of tetraethyl.

The permanent discharges supplant a previously-announced plan to temporarily lay off about 400 workers in June. Ethyl employs about 3,900 workers at Baton Rouge.

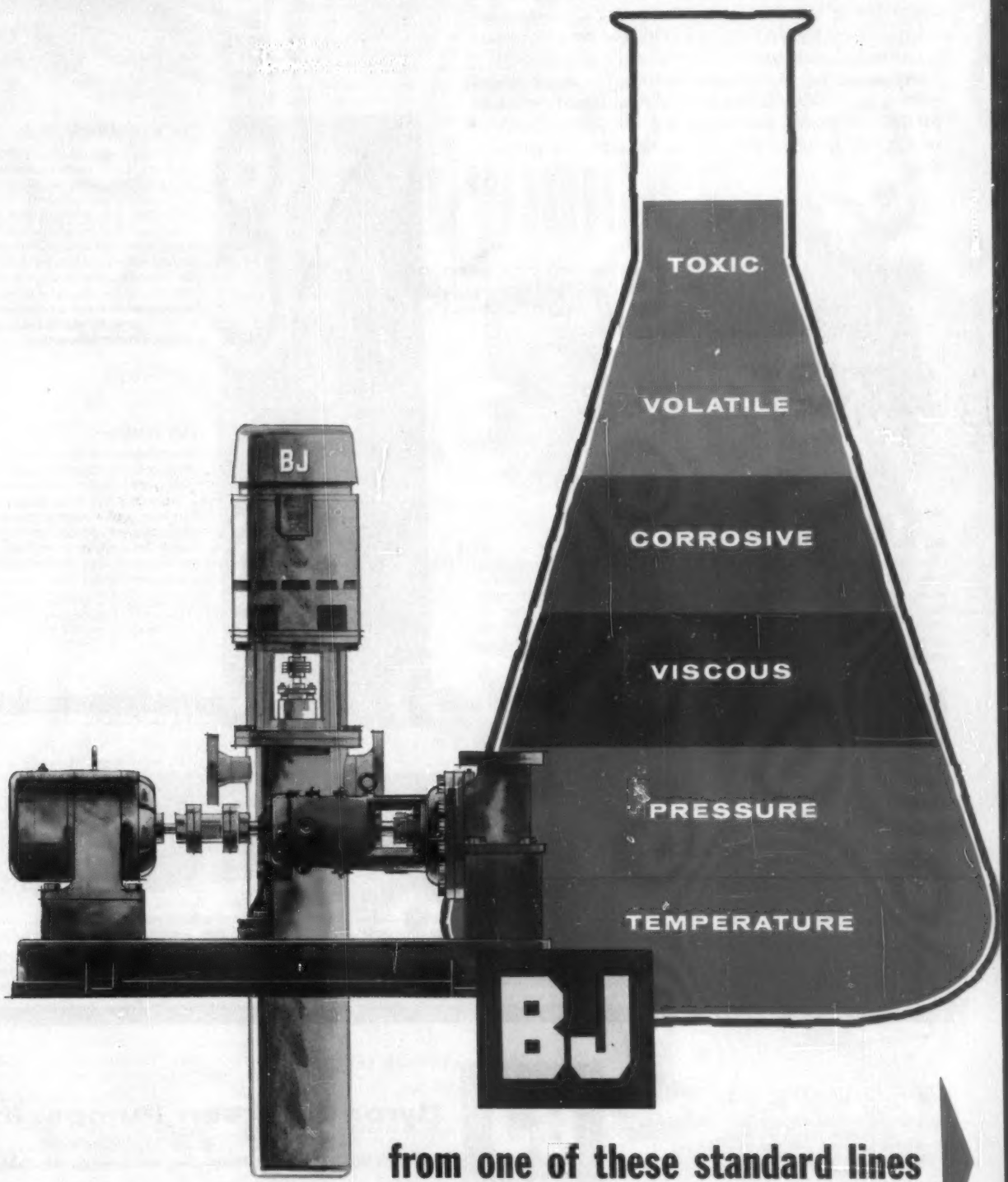
Gloomy Outlook for Coal

Interior Secretary Seaton has urged Congress to give a 27.5 percent depletion allowance to oil shale, coal, and other natural deposits when they are used as a source of synthetic liquid fuels.

Bituminous coal research spokesman

Name your toughest pumping job...

BJ CAN MATCH IT WITH A RELIABLE PUMP!



from one of these standard lines

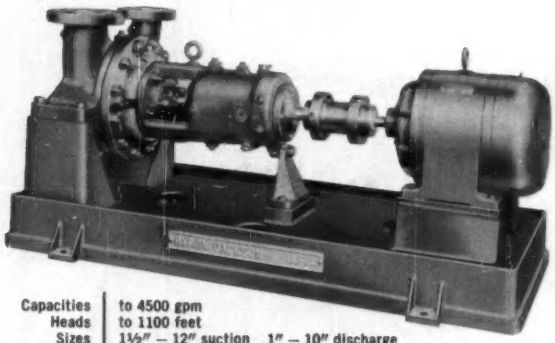
BJ Standard Pumps—engineered to your process handling requirements!

WHILE RELIABILITY IS the most important single feature demanded in a process pump, operating conditions are often the most rugged. Extremes of high or low temperature . . . corrosive, toxic and volatile fluids are encountered.

As part of Byron Jackson's complete line of centrifugal pumps, the models shown here were designed especially for different process pumping conditions. *All are available with the BJ Mechanical Seal for dependable, top performance.*

BJ MECHANICAL SEAL

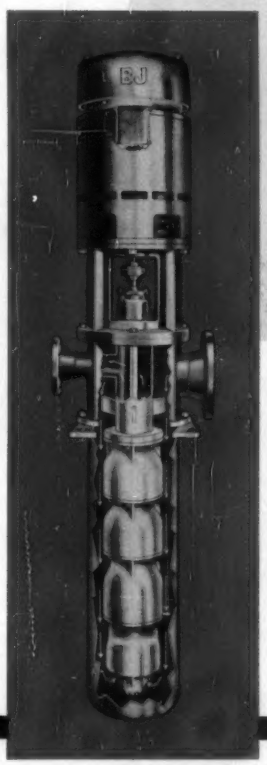
Replaces standard stuffingbox packing. Eliminates excessive leakage, frequent repacking and shaft sleeve replacement. Materials and construction combinations for almost any corrosion, pressure, temperature or liquid handling need. Since BJ manufactures both mechanical seals and pumps, you are assured of a completely reliable process pump from a single, responsible source.



Capacities	to 4500 gpm
Heads	to 1100 feet
Sizes	1½" – 12" suction 1" – 10" discharge
Temperatures	−320°F to 800°F

SM PROCESS PUMPS

Developed for handling fluids over a wide range of pressures and temperatures. Basically a single stage, single suction horizontal pump, the SM Series is designed for continuous operation with easy dismantling for inspection or service. Ideal for pumping hot or cold liquids near vapor pressure . . . for corrosive or non-corrosive service. Two stage, as well as double suction models available . . . also models with integrally-built BJ Mechanical Seals.



VMT PUMPS

Mounted in a self-contained suction sump, ideal for use where net positive suction head is limited. Saves floor space. Single or multi-stage to meet the particular job. Sump barrel length determined by NPSH requirement. For corrosive or non-corrosive service.

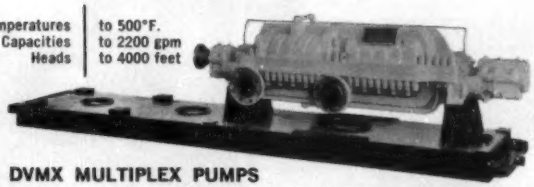
Temperatures	−320°F to 550°F
Capacities	to 9000 gpm
Heads	to 2000 feet

VERTICAL CIRCULATING PUMPS

High efficiency with medium-to-high capacities. Single or multi-stage, turbine type units have simplified piping and installation . . . use little floor space.

Pump sizes	16" to 57"
Capacities	to 45,000 gpm
Total head	500 feet

Temperatures	to 500°F.
Capacities	to 2200 gpm
Heads	to 4000 feet



DVMX MULTIPLEX PUMPS

Compact design with double row bolting prevents interstage leakage or bowing at parting flanges — even at 4000 psi hydraulic pressures! Symmetrical design allows safe operation to 500°F . . . metallurgy and construction permit speeds to 7000 rpm. Easily adaptable for interstage take off at intermediate pressures.

BJ OFFERS A COMPLETE LINE of pumps to answer almost any need. Send us your job description for a specific recommendation.

BJ SINCE 1872

Byron Jackson Pumps, Inc.

A Subsidiary of Borg-Warner Corporation

P.O. Box 2017, Terminal Annex • Los Angeles 54, California

PRINTED IN U.S.A.

Harold J. Rose, has told Congress that the outlook for production of synthetic fuel from coal is not good. In response to questions from the House Interior subcommittee on mines and mining, Rose said no substantial progress has been made in making synthetic fuel from coal on a basis that would make the coal industry a big competitor of petroleum.

Rose added that "when the time comes, as the supply of petroleum and natural gas diminishes and prices go up accordingly, fuel will be made from coal, and the demand for coal for these purposes will be fantastic."

Asked if he sensed any shift from gas to coal in heavy industry, Rose replied, "Yes, but there again it is largely a matter of price. It is a marketing policy to have dump-load gas rates. In the summer months, when the residential house load falls off, coal is sold cheaply to industry."

Hydrogenation Gas Plant To Be Featured At Olympia

A model of a revolutionary plant to be built at Partington, England, near Manchester to produce gas by hydrogenation of oil or low-grade coal will be displayed by Humphreys and Glasgow, Ltd., on their stand at the first Chemical and Petroleum Engineering Exhibition at Olympia in June.

This $5.6 million plant, which resembles a modern chemical plant rather than a conventional gasworks, will be in operation by the beginning of 1960. With a daily capacity of 7.5 million cubic feet of gas, it is regarded by the gas industry and by the government as a full-scale demonstration unit to prove the efficiency and economics of the new process. Household gas will be produced at high pressure by a sequence of continuous automatically controlled processes. The whole project was designed by the process engineering department of Humphreys and Glasgow, Ltd., in collaboration with the development department of the North Western Gas Board. Partington is the first plant of its kind in the country.

L. A. High School Students Hear Shell Science Lectures

Science students in Los Angeles are learning about hydrocarbons and petroleum research directly from oil men, scientists, and engineers from Shell Oil Co. and Shell Chemical Corp., who are now delivering lecture-demonstrations to advanced high school science classes on a regularly scheduled basis.

The talks are part of a new "Industry-Education Program in Science and Mathematics" inaugurated this school year by the Los Angeles City schools, the first organized program of its kind in the U. S. Its purpose is to stimulate the high school student's appetite for more science—and to let him learn firsthand what kind of people scientists are and what they do on their jobs.

From the beginning these educational "task forces from industry" have received the full support of educators and companies alike and a total of nine companies and 77 scientists are now participating. Guest lecturers visit the schools on company time and often take along unusual research tools used on the job.

Gasoline Probe Out for Year

The planned congressional investigation of gasoline surplusses probably won't be held this year according to Chairman Roosevelt (D-Calif.) of the House Small Business subcommittee.

Hearings were to be started in April but Rep. Patman (D-Tex.) had expressed a desire that the full committee hold any hearings on the gasoline situation. Patman is chairman of the parent committee.

Roosevelt said no other petroleum investigations are expected by his committee this year. He noted that the last report of the subcommittee assured companies that the group would withhold any investigations or legislative efforts this year and give companies an opportunity to improve dealer relations.

What's Happening. . .

Premium Stable, Regular Up According to Octane Report

Gasoline on sale at service stations in May showed national weighted averages of 98.5 octane number for premium and 91.2 octane number for regular, according to the latest monthly survey of antiknock quality compiled by Ethyl Corp. Compared with April, 1957 and 1958 the premium average was unchanged, but regular was 0.1 octane number above last

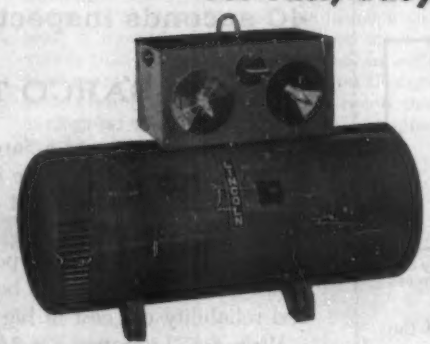
Weldynamics

ARC WELDING AT WORK CUTTING COSTS

Set the job selector

Dial the welding heat

for fast, easy, low-cost welding



Shield-Arc motor-generator welders are available in 200, 300, 400 and 600 amp. sizes; portable or stationary; for AC or DC power supply. Specifications and engineering data are contained in Bulletin SB-1362, sent on request.

Dual continuous controls on the Lincoln Shield-Arc let you select both arc intensity and welding current for the best performance on your job. Because of this exacting arc control, welding high alloy and stainless steels becomes efficient routine.

For structural and maintenance welding in refineries no welder can match Shield-Arc for utility and versatility.

The World's Largest Manufacturer of Arc Welding Equipment

© 1958 The Lincoln Electric Company

LINCOLN

THE LINCOLN ELECTRIC COMPANY • DEPT. 2215 • CLEVELAND 17, OHIO

For more data on advertised products, use Readers' Service Cards, last page.

Simplicity in steam traps can effect big savings in parts inventory and maintenance time

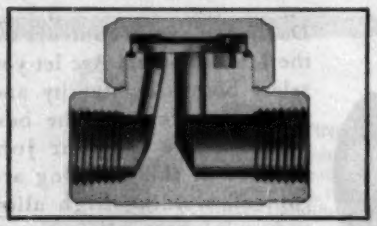
by John W. Ritter, Test Engineer
SARCO Company, Inc.

The function of all steam traps is to release condensate and prevent steam loss. However, the method of trapping can make a great difference in cost and effectiveness.

In the Sarco Thermo-Dynamic Steam Trap, the method is fundamental. Air or condensate entering the trap must flow from the inlet tube, radially across the underside of the disc valve, to the outlet. The space between the inlet tube and the disc forms a nozzle in which the static pressure energy of the incoming fluid is partly changed to velocity across the underside of the disc, with a resultant *decrease* in pressure. (This will be recognized, of course, as the Bernoulli Principle.) Use of this fundamental method means reliability in operation.

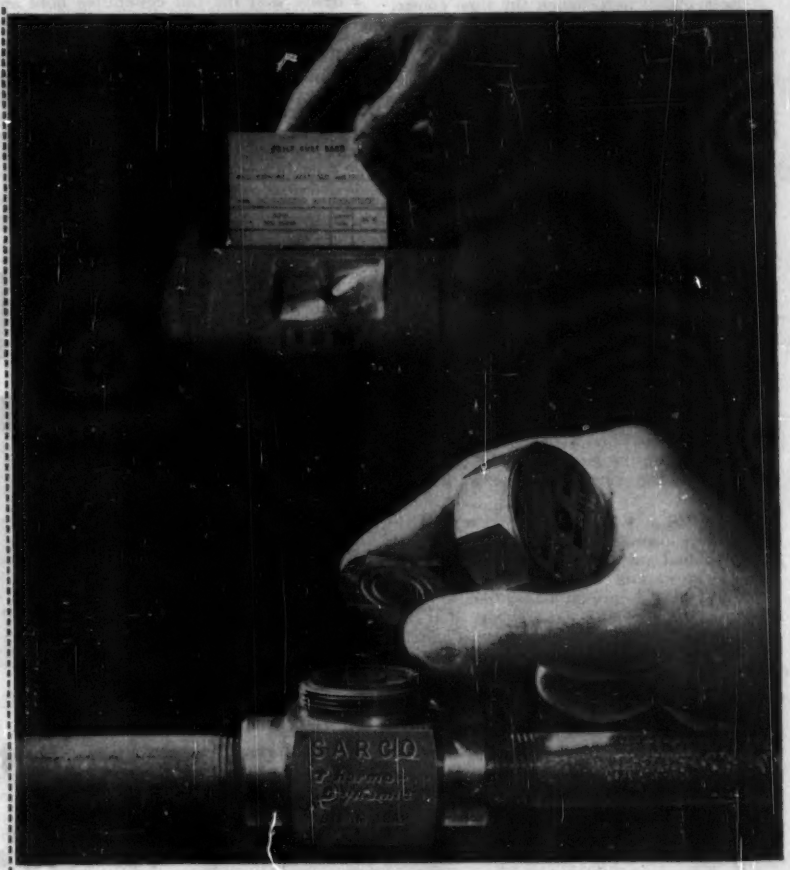
As the high velocity fluid jet strikes the side of the upper chamber, some recompression takes place, so that the pressure above the disc becomes greater than the pressure below it. The pressure reduction under the disc and the pressure recovery above it depend on the internal energy of the fluid. As the condensate above nearly approaches steam temperature, its internal energy is enough to overcome the upward force at the inlet tube and the disc snaps down in the inlet tube, which is the inlet valve seat.

Simultaneously, the disc also seals the outer ring, which isolates the space above the disc from the outlet. The disc valve is therefore held firmly against the inlet valve seat until the pressure in the control chamber is reduced by condensation. The upward force then exceeds the downward force and the disc valve opens.



This 3-part Sarco TD Steam Trap has only one moving part—the hardened, polished stainless steel disc.

No other trap uses the velocity of the fluid to operate the valve or uses the recompression of the flowing fluid to trap the valve closed and to hold it closed. When it closes, it closes tightly—no "operating steam" leaks out.



40 seconds inspection time— that's all it takes for a SARCO TD Steam Trap

Just back off the cap of a Sarco TD. Lift out its single moving part, the stainless steel disc. Wipe it off, and drop it back. No adjustment is ever required, at any load or any pressure in its range—from 10 through 600 psi.

The TD operates in any position, won't blow steam at any load. Small as a tee fitting, it can be installed in tight places. Its versatility and reliability cut cost of big replacement inventory.

Write for "Literature Kit 2A" today and get latest bulletins on the TD Steam Trap and other Sarco steam traps. Remember that Sarco can give you impartial advice on *Production Planned steam trapping* because . . .

5605-B

SARCO
COMPANY, INC.
635 Madison Ave., New York 22, N. Y.

Only Sarco makes all 5 types:
Thermostatic • Liquid Expansion • Float Thermostatic
Thermo-Dynamic • Bucket

STEAM TRAPS • TEMPERATURE CONTROLLERS • STRAINERS • HEATING SPECIALTIES

What's Happening. . .

month and 0.4 octane number over April, 1957.

Average tetraethyl lead contents in May were 2.49 ml per gallon of premium gasoline and 1.85 ml per gallon of regular gasoline.

For companies marketing more than one grade of premium, the survey showed a range of 100.0 to 103.0 octane number for the highest grade, on the basis of 40 samples in 20 cities.

Twenty-four of the 57 cities in Ethyl's survey reported increases over April in the average octane number of their premium gasolines, three by over 0.5 octane number. Twenty-one cities reported decreases and 12 cities were unchanged. In regular gasoline, 21 cities reported increases over April in their average antiknock quality, one by 0.5 octane number. Twenty-one cities reported decreases while 15 cities were unchanged.

Compared with the nationwide premium average of 98.5 octane number, seven cities reported premium averages of 99 octane number or higher. In regular gasoline, 16 cities showed average octane ratings of 92 octane number or higher, compared with the national weighted average of 91.2 octane number.

–Changing Times–

Fluor Products Co. of Canada has been established as a **separate division of the Fluor Corp. of Canada, Ltd.**

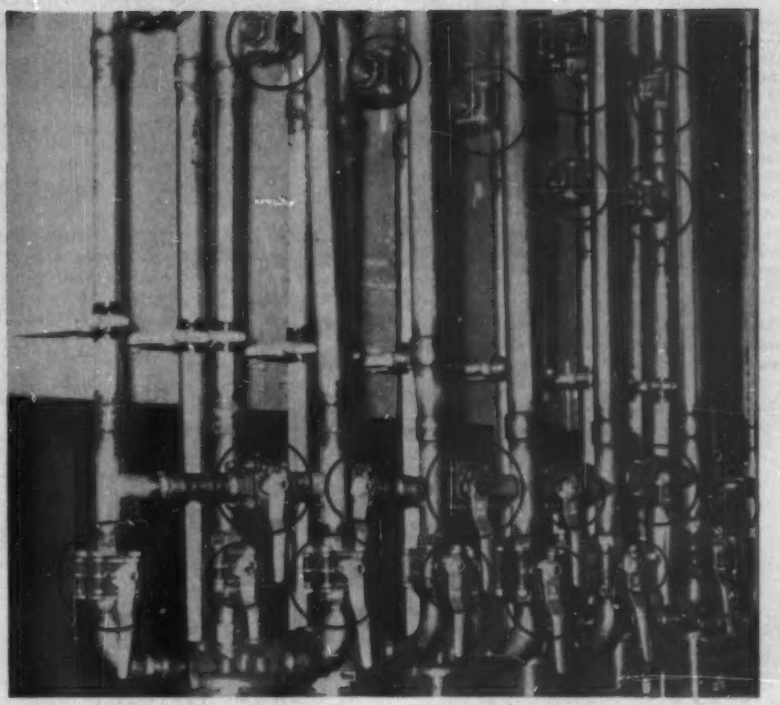
Strike threat at Indiana Standard's 210,000-bpd Whiting, Ind., refinery **was quashed when** the 5,400 member Independent Petroleum Workers of America received a **$.045 to $.07 wage increase offer from company.**

An Arizona Planning and Zoning Commission unanimously **rejected Bishop Oil & Refining Co.'s application to build** a $19 million refinery at Beardsley, 20 miles northwest of Phoenix. The commission said **"growth of this area is dependent on clean air."**

A Pennsylvania steel man said **steel companies could be more helpful to oil companies if they were invited to discuss materials problems at earlier stages** than is the custom in most instances. **Charles L. Huston, Jr., made the remark** at the recent API division of refining meet in Los Angeles.

First shipment of LPG produced in Venezuela for export was loaded last month at Creole's La Salina dock # 3 aboard the M.S. Marion P. Billups. Bound for Caribbean markets, **the LPG was produced at Creole's new Ule's Gas Liquefying plant** in Bolivar district.

House Small Business subcommittee **recently held hearing to examine** Small Business Administration's new definition of a small business, including **a special definition of petroleum.** New definition of



Only the ECON-O-"MISER" Ball Valve was able to solve this problem for PathéColor, Inc.

THE PROBLEM: To find a valve that would meet all of the following requirements:

1. Quick visual indication of position and quarter turn operation. 2. Excellent flow characteristics and positive shut-off. 3. The advantages of flange construction without the bulk and weight of conventional flanged valves. 4. Easy & quick disassembling for low cost maintenance. 5. The most compact and economical installation of Type 316 stainless steel valves possible.

SOLUTION: *Specifying* and *installing* Worcester's Econ-o-"miser" Ball Valve. In so doing PathéColor found a valve that provides a positive seal, a flanged construction much more compact than conventional valves that could be socket welded. In addition many unions and companion flanges were eliminated with the overall result that savings on this installation alone amounted to many hundreds of dollars.

Valves available, ¼"-2", in following standard materials*: Bronze, Aluminum Bronze, Aluminum, Carbon Steel and Types 303 and 316 Stainless Steel. Standard Seat and O-Ring materials*: Buna-N, Neoprene, and Teflon.

**Other materials available on request.*

For further information and descriptive literature write to:

WORCESTER VALVE CO., INC.

16 PARKER STREET • WORCESTER, MASS.

For more data on advertised products, use Readers' Service Cards, last page.

small refiner was those with not more than 1,000 employes and throughout capacity of 30,000 bpd or less. **Many independent refiners objected.**

About 100 million **economy-sized autos will crowd U. S. highways in 2000 A.D.,** says Daniel P. Bernard, research coordinator for Standard of Indiana. Gas turbine engine **won't be too influential** in next ten years—demand for petroleum products **will continue to grow**—greatest relative **growth will be in petrochemicals,** said Bernard.

Dowell, Inc., wholly owned subsidiary of Dow Chemical Co., **is now a Dow division. There will be no change in management** or location of Tulsa office. Dowell's Latin American and Canadian subsidiaries join in the move.

Iraq government has advertised coming sale of **37 million barrels of royalty crude for delivery during 1959.** Oils are produced from Kirkuk, Ain Zalah, and Zubair fields, and will be available at Banias, Tripoli, and Fao terminals.

Humble Oil & Refining Co. **has discontinued operation of the Butadiene unit at its Baytown refinery for an "indefinite period."** It said action was taken because of continuing low demand for butadiene as an ingredient in synthetic rubber and for other chemical uses.

Changes in Ownership

Flank Oil Co., wholly-owned subsidiary of Asamera Oil Corp., has purchased assets of 11 companies engaged in refining, producing and marketing in the Wyoming-Colorado area. Purchase includes Oriental Refining Co., Denver, Sheridan Crude Oil Purchasing Co., and other companies in the "Stringer-Zall" group with headquarters in Denver.

The sale of Shell Oil Co. of Palestine (Shell and British Petroleum) involved less than $11-million, it has been announced.

The purchaser, Iwol Investments, was newly formed by a group headed by Isaac Wolfson, chairman of Great Universal Stores. Shell Co. of Palestine sold about 40 percent of 1.3-million tons of products consumed in Israel last year. No decision has been reached on British Petroleum-Shell's 80,000-bpd refinery at Haifa. It processed 16,000 bpd last year.

Forest Oil Corp. has sold its interest in Dora Roberts field, Midland County, Texas, to General American Oil Co., Dallas, for $16-million. Forest will get 90 percent of this sum in oil payments and 10 percent in cash.

General American estimates its net reserves recoverable from Forest interest at 13-million barrels of crude and condensate, and 60-million Mcf of gas. General American will also receive Forest's interest in a natural gas plant serving field and its interest in 9,000 undeveloped acres.

Golden Eagle Refining Co., wholly-owned subsidiary of Panama Refining and Petrochemical Co., Panama, S.A., has purchased Sunset International Petroleum Co.'s refining, marketing, pipeline, and terminal facilities.

The transaction involved a "large cash payment," with Sunset International receiving a stock interest in Panama Refining and "providing Golden Eagle with management."

Cities Service Oil Co. has acquired the Stonewall gasoline plant from The Liquigas Co. of Dallas.

The plant is in the northeast corner of Stonewall County, Texas. A gathering system with 5 automatic booster stations which extends approximately 30 miles from the plant into the southern part of Stonewall County, handles 15 million cubic feet of gas daily from 12 small oil fields in the area. The plant was built in 1954, and is presently producing approximately 75,000 gallons of natural gas liquids daily.

A new company, Cyanamid-Ketjen N.V. has been founded by American Cyanamid Co., N.Y., and Koninklijke Zwavelzuurfabrieken v/h Ketjen N.V., Amsterdam, both of them participating for equal parts in the capital of the new company.

Hooker Electrochemical Co., Niagara Falls, N.Y., and Shea Chemical Corp., New York, N.Y. approved a formal agreement for the consolidation of the two companies subject to the approval of the stockholders of each company.

Under the terms of the proposed consolidation, Hooker will be the continuing company and its name will be changed to **Hooker Chemical Corporation.**

When Was Zinc Chromate First Used in Corrosion Inhibitors?

Over 10 years ago, in 1947, Wright introduced the use of zinc, for corrosion control, in a new Wright product called Penechrome Z. Since then other Wright Penechromes, containing zinc chromate and organic additives, have proved in years of field service the greater effectiveness of zinc-containing corrosion inhibitors. Wright research, as always, will continue developing new approaches to the solution of your water side corrosion problems.

Ask about Wright Consulting Services.

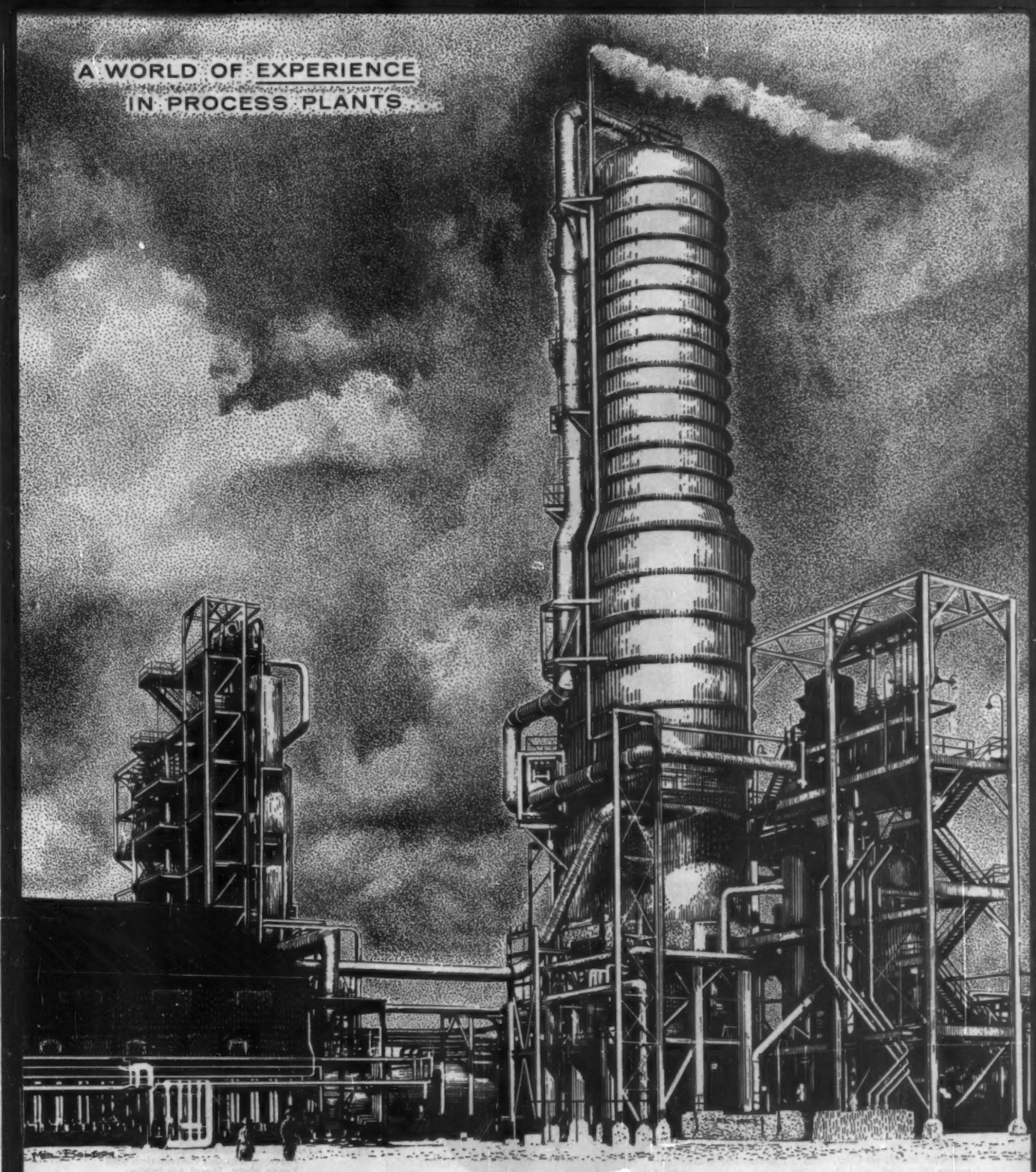
Wright CHEMICALS

WRIGHT CHEMICAL CORPORATION

GENERAL OFFICES AND LABORATORY
633 WEST LAKE STREET, CHICAGO 6, ILLINOIS
Offices in Principal Cities

- Softeners, Filters and other external Treating Equipment
- Nelson Chemical Proportioning Pumps

For more data on advertised products, use Readers' Service Cards, last page.



FOSTER WHEELER *in Venezuela . . .*

Completed and on stream at Amuay —

4 Crude Units, 329,000 b/d
Fluid Hydroforming
Hydrofining
Complete Lube Facilities
Treating, Rerunning, Offsite

all designed and constructed by

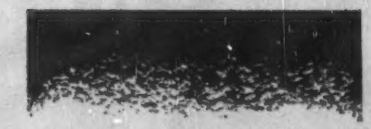
Foster Wheeler Corporation, 666 Fifth Ave., New York 19, N.Y.

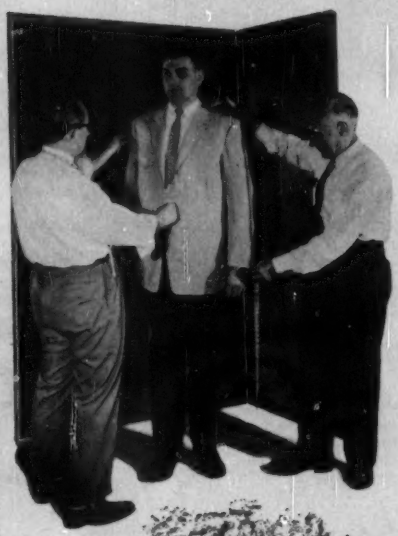
DESIGN
ENGINEERING
CONSTRUCTION

Petroleum Plants
Petrochemical Plants
Chemical Plants

NEW YORK • LONDON • PARIS • ST. CATHARINES, ONT. • TOKYO

A Perfect Fit

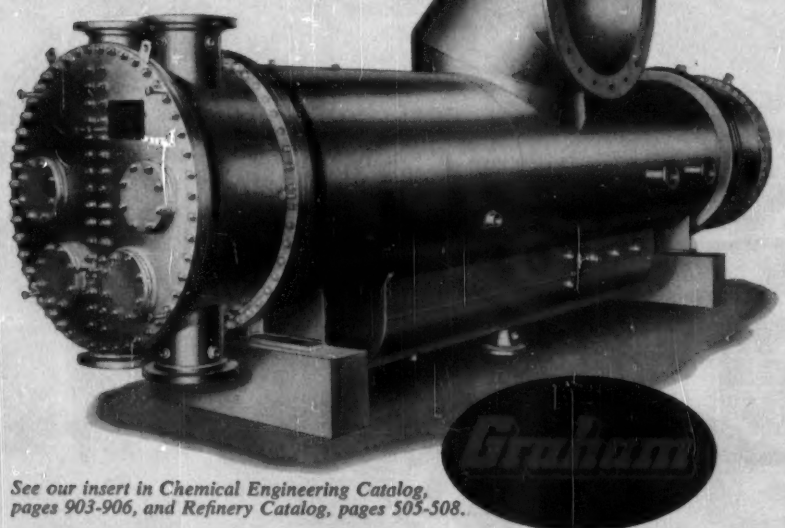




In a like manner **Graham Surface Condensers** and **Steam Jet Ejectors** are tailor made for your particular needs—truly a perfect fit! The finest possible performance, proportioned to efficiently fit your space conditions plus rugged construction for a minimum of upkeep—are the result of building over ten million square feet of Surface Condensers throughout the past quarter century.

The many practical features that are incorporated with great detail into each Graham design conclusively prove that there is no substitute for experience.

Call Graham on your next condenser problem without obligation.



See our insert in Chemical Engineering Catalog, pages 903-906, and Refinery Catalog, pages 505-508.

GRAHAM MANUFACTURING CO., INC.

415 LEXINGTON AVE., NEW YORK 17, N. Y.

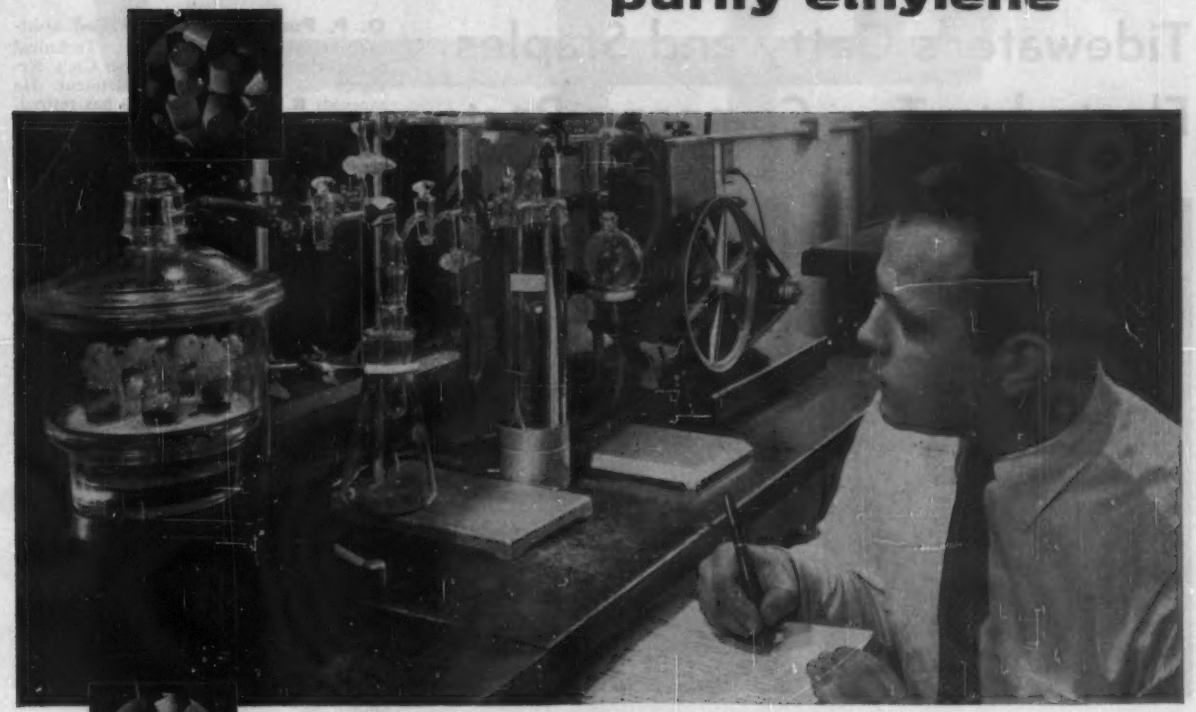
Offices in principal cities and Canada

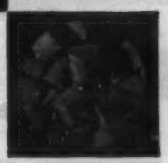
Heliflow Corporation

MEETINGS CALENDAR

1958	
JUNE	
18–28	Chemical and Petroleum Engineering Exhibition, Olympia, England.
22–27	American Institute of Chemical Engineers, 50th Anniversary Meeting, Bellevue-Stratford Hotel, Philadelphia.
22–28	American Society For Testing Materials, Annual Meeting and Exhibit, Hotel Statler, Boston.
25–26	Western Petroleum Refiners Assn., Mid-Continent Regional Technical-Industrial Relations Meeting, Broadview Hotel, Wichita, Kan.
JULY	
24–25	Fifth Annual Symposium on Computers and Data Processing, Albany Hotel, Denver.
AUG.	
11–14	Society of Automotive Engineers, National West Coast Meeting, Ambassador Hotel, Los Angeles.
18–21	American Institute of Chemical Engineers, Heat Transfer Meeting, Northwestern University, Evanston, Ill.
SEPT.	
3– 5	American Petroleum Institute, Oil Information Committee Meeting, Hotel Statler, Boston.
3– 5	Cryogenic Engineering Conference, Massachusetts Institute of Technology, Cambridge, Mass.
4– 5	American Society of Mechanical Engineers, International Conference on Air Pollution, Hotel Statler, N.Y.
10–12	National Petroleum Assn., 56th Annual Meeting, Traymore Hotel, Atlantic City, N.J.
15–19	American Society of Mechanical Engineers, Process Industries Conference, Hotel Statler, Buffalo, N.Y.
15–19	Instrument Society of America, Annual Instrument Automation Conference and Exhibit, Phil.
18	Natural Gasoline Assn. of America, Rocky Mountain Regional Meeting, Gladstone Hotel, Casper Wyoming.
21–24	American Society of Mechanical Engineers, Petroleum Mechanical Engineering Conference, Cosmopolitan Hotel, Denver.
22–24	Standards Engineers Society, 7th Annual Meeting, Benjamin Franklin Hotel, Philadelphia.
24–25	Western Petroleum Refiners Assn., Rocky Mountain Regional Technical-Industrial Relations Meeting.
28–Oct. 1	American Society of Mechanical Engineers' Power Conference, Hotel Statler, Boston.
OCT.	
1– 2	Western Petroleum Refiners Assn. Third Annual Stream Pollution and Waste Disposal Conference, Lassen Hotel, Wichita.
6– 8	National Assn. of Corrosion Engineers, Northeast Regional Meeting, Boston.
9–10	American Society of Mechanical Engineers Fuels Meeting, Old Point Comfort Hotel, Old Point Comfort, Va.
13–15	National Electronics Conference, 14th Annual Forum on Electronic Research, Development, and Application, Hotel Sherman, Chicago.
13–15	American Gas Assn., Annual Convention, Atlantic City, N. J., Site Unreported.
15–17	Second Energy Resources Conference, "Energy and Its Impact on Society," Brown Palace Hotel, Denver.
19–21	National Assn. of Oil Equipment Jobbers, Annual Convention and Trade Show, Hotel Adolphus, Dallas.
20–24	National Assn. of Corrosion Engineers, Annual Conference and Exhibition of South Central Region, Roosevelt Hotel, New Orleans.
22–24	Society of Automotive Engineers, National Meeting, Lord Baltimore Hotel, Baltimore, Md.
23–24	Western Petroleum Refiners Assn., Session on Refinery Technology and Industrial Relations Meeting, Rufus Garrett Hotel, El Dorado, Ark.

How Girdler helps you purify ethylene





Problem: Removal of acetylene from ethylene streams to meet "acetylene free" product specifications.

Process: Continuous selective hydrogenation in the raw cracked gas stream.

Solution: Girdler's Research and Development Department formulated and tested several catalyst preparations under simulated plant conditions. The requirements of activity and selectivity were met.

Result: Successful commercial operation of Girdler catalysts giving product ethylene with *less than 20 p.p.m. acetylene.*

You are assured optimum performance with Girdler catalysts because *your* process variables are given individual consideration . . . and because you have the help of Girdler's complete Technical Service at all times.

GIRDLER MANUFACTURES CATALYSTS FOR:
HYDROGENATION
SYNTHESIS GASES AND HYDROGEN GENERATION
DESULFURIZATION
NEW CATALYTIC PROCESSES

GIRDLER CATALYSTS

Louisville 1, Kentucky

CHEMICAL PRODUCTS DIVISION • CHEMETRON CORPORATION

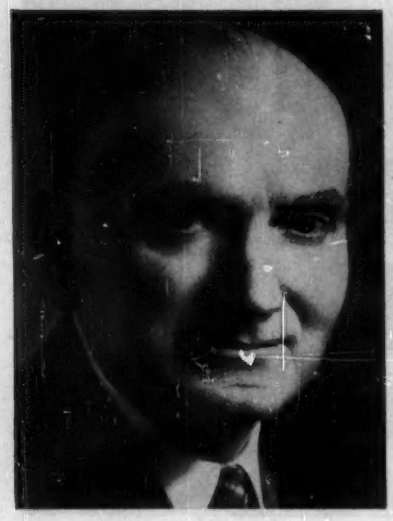
CHEMETRON

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening . . .

. . . *Among Men* in the Industry

Tidewater's Getty and Staples Elected to Top Company Posts



David T. Staples

George F. Getty II

David T. Staples has been elected chairman of the board of directors of Tidewater Oil Co. Succeeding him as president is George F. Getty II, who advanced from his previous post as vice president and general manager of the company's eastern division.

Getty entered the petroleum industry in 1947 as an independent oil operator. He served as manager of the Saudi Arabian division of Pacific Western Oil Corp. (now Getty Oil Co.) in 1949 and 1950, manager of its mid-continent division in 1952 and executive vice president and director in 1955. From 1953-55 he served as vice president and director of Spartan Aircraft Co., Tulsa, and as president of its subsidiaries, Minnehoma Financial Co. and Minnehoma Insurance Co. He was first elected to the Tidewater board two years ago, at which time he became vice president and general manager of its eastern division.

Staples studied law in Victoria under the British Columbia Law Society. In 1921 he became a member of the California Bar, serving the oil industry there in a legal and executive capacity for many years. After service with Shell Oil Co. for many years, he joined Pacific Western Oil Corp. and later became its executive vice-president and a director. In 1952 he was elected a member of the board of directors of Tidewater Oil Co. and a year later became president. Staples is also a vice-president and director of the Mission Development Corp. and a director of the Hotel Pierre in New York City.

D. C. Walsh has just been promoted to senior coordination technician at Humble Oil & Refining Co's., Baytown, Texas, refinery in the Coordination division. **D. E. Bown** has been promoted to senior research chemist in the Research and Development division. In the Engineering division, **C. Bultzo** has been promoted to senior mechanical engineer, and **C. H. Carney** and **R. L. Martin**, to senior design engineers.

Walsh and Carney hold B.S. degrees in chemical engineering from Louisiana State University, and Martin from Texas University. Bown has a B.S. degree in math and chemistry, a M.S. degree in chemistry from Brigham Young University, and a Ph.D. degree in chemistry from M.I.T. Bultzo has a B.S. degree in mechanical engineering from University of New Mexico.

O. P. Puryear has been named assistant manager (Industrial), Technical Services division of The Texas Co.'s Research and Technical department. He succeeds **R. R. Thurston**, who has retired.

Louis E. Endsley, Jr., has been named to succeed Puryear as assistant manager (Operations), Technical Services division. Endsley was formerly director of technical services of the Texaco Research Center, Beacon, N. Y.

Other changes at the Research Center, the Company's largest research facility, were: **J. Stanley McKeown** succeeds Endsley as director of technical services. **Albert D. Togna** succeeds McKeown as supervisor of the Field Service department. **August Sellingsloh** succeeds Togna as supervisor of the Products Testing department. **Joseph L. Furtnett** succeeds Sellingsloh as assistant supervisor of the Analytical department. **Neil H. Fick**, formerly group leader in the Products Testing department, succeeds Furtnett as chemist (Staff) in Technical Services Administration.

Walter L. Bass has rejoined The Rust Engineering Co. as assistant to the vice president, engineering. For the past three years, Bass had been in Paris as a project manager for the Lummus Co. where he was responsible for the design and construction of a new oil refinery in Finland.

Prior to the foreign construction work, he was a chemical process engineer with Rust in Pittsburgh.

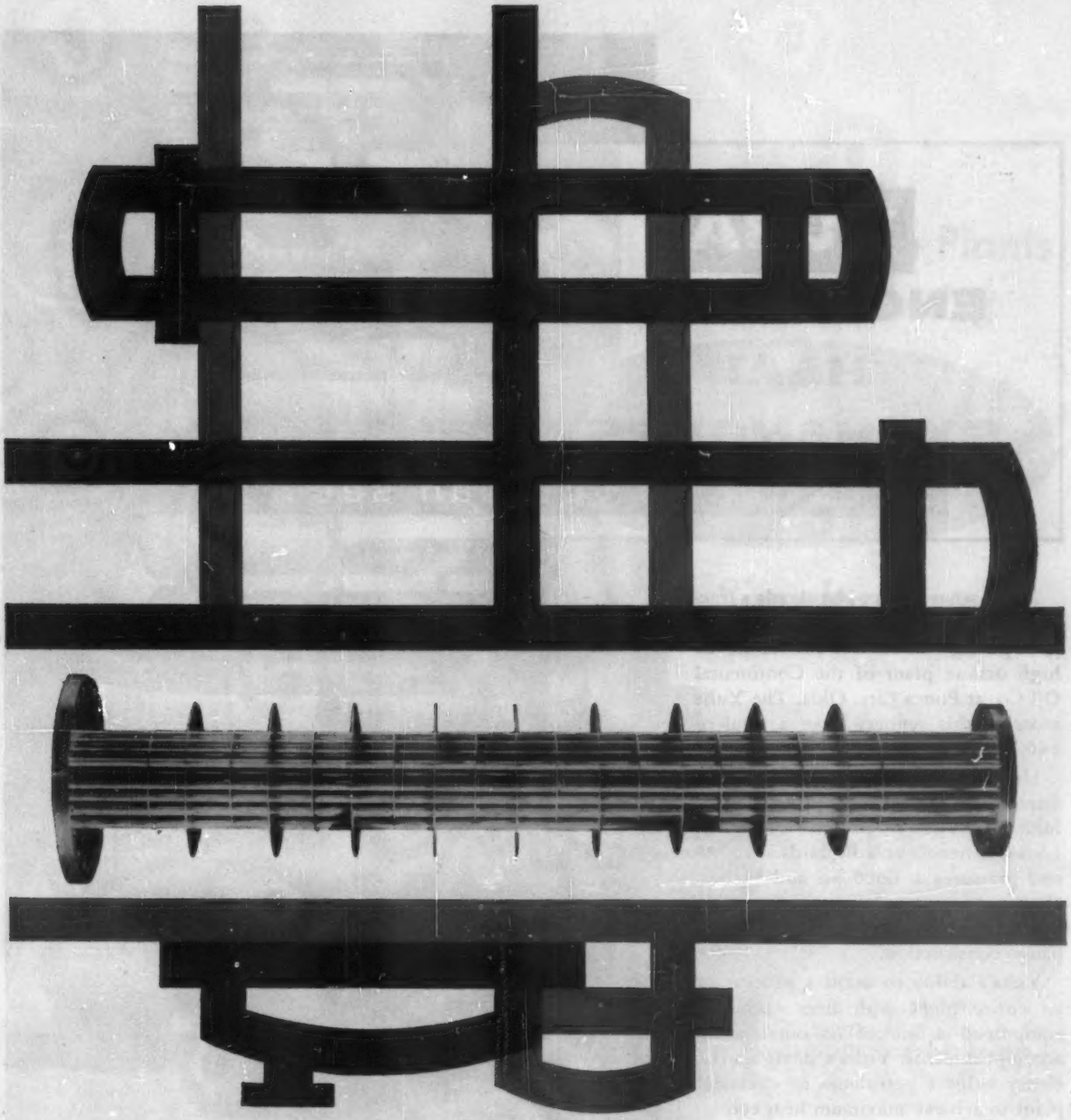
Bass received his B.S. degree in chemical engineering from Cooper Union and also studied at the Polytechnic Institute of Brooklyn.

Reginald N. Blaize was nemed president and chief operating officer of Eastern States Petroleum & Chemical Corp. at the company's annual meeting of stockholders. He has been executive vice president of the company since 1950.

Blaize

Richard B. Kahle, president of the company since its founding, has become chairman of the board of directors and chief executive officer of the company, **Joseph F. McCarthy**, one of the founders of the company, who has been marketing vice president and for the last several years chairman of the board, becomes the chairman of the executive committee.

Blaize's entire business career has been spent in various phases of the oil industry. After receiving his degree in chemical engineering from Louisiana State University



win the fight against corrosion—with Alcoa Aluminum

Here's a $100-million example. The refining industry's requirements for heat exchanger tubes are 40 ft per barrel of capacity. Some 30 ft of this requirement involves exchanger applications in which Alcoa has proved aluminum is ideal. By using aluminum tubes in all those applications, the refining industry would have saved approximately $37 million in original capital investment. Capitalized at the refining industry's normal rate of return, that saving would be worth about $100 million over a 10-year operating period.

Don't shovel good money after bad by reinstalling unsuitable material. Over 30 years' experience in the process industries has given Alcoa engineers full knowledge of the aluminum alloys and installation methods by which corrosion can be eliminated. Put their knowledge to work for you. Outline your corrosion problems in a letter to ALUMINUM COMPANY OF AMERICA, 905-F Alcoa Building, Pittsburgh 19, Pa.

"ALCOA THEATRE"
Exciting Adventure
Alternate Monday Evenings

ALCOA CHEMICALS

Specify Alcoa Aluminum for
corrosion-free Process Equipment
Pipe & Tube
Tanks, Containers, Trucks & Cars
Plant Structures

For more data on advertised products, use Readers' Service Cards, last page.

YUBA
ENGINEERED HEAT EXCHANGERS
as far as you can see . . .

. . . and what you see is still only a fraction of the more than 100 heat exchangers giving trouble-free service in the high octane plant of the Continental Oil Co. at Ponca City, Okla. The Yuba units in this refinery have a total of 140,418 sq. ft. of heating surface.

Heat exchangers for petroleum refineries and for chemical plants can be built with Yuba's well-known *Multilok Closure* to handle volatile fluids at 1200F and pressures at 6000 psi and higher. Heat exchangers in lower pressure-temperature ranges have standard bolted flange construction.

Yuba's ability to outfit a process or an entire plant with heat exchange equipment is one of its outstanding accomplishments. Yuba's design efficiency helps a petroleum or chemical plant to achieve maximum heat economy and, as a result, helps it to lower its manufacturing costs significantly.

Consult Yuba on your next heat exchanger order. You will find its East-West manufacturing and sales facilities very convenient.

YUBA CONSOLIDATED INDUSTRIES, INC.

351 CALIFORNIA STREET, SAN FRANCISCO 4, CALIFORNIA

Divisions Manufacturing Heat Exchangers

ADSCO DIVISION, Buffalo, New York

YUBA HEAT TRANSFER DIVISION, Honesdale, Pennsylvania

YUBA MANUFACTURING DIVISION, Benicia, California

YUBA

San Francisco Sales Office:
520 Balfour Building

New York Sales Office:
530 Fifth Avenue

Sales Offices and Representatives in Principal Cities

For more data on advertised products, use Readers' Service Cards, last page.

Men in the Industry . . .

he was employed by the Lion Oil Co. in El Dorado, Ark., until he came to the Eastern States Engineering Department in 1940, where he was soon appointed chief engineer. He was promoted shortly thereafter to manager of refining, and in 1950 was elected executive vice president.

Oscar Larson has been promoted to manufacturing manager of Tidewater Oil Co.'s seven state and Hawaii western division. He succeeds **Thomas O. Edwards** who recently retired after 37 years with the company.

Larson

Larson started his career with Tidewater in 1923 as a pipefitter helper at the company's Avon refinery near Martinez, Calif., and has held successive positions there as still foreman, SO_2 operator, edeleanu operator, plant foreman, tract superintendent, process superintendent, and assistant refinery manager. In 1955 he was appointed manager of the Avon refinery.

He is a graduate of the University of Wyoming with a B.S. degree.

J. E. Fenex, Denver, manager of Continental Oil Co.'s refineries in the Rocky Mountain region for the past 10 years and a veteran of 36 years with the company's Manufacturing department, retired May 31. He joined Conoco as a stillman at the company's Glenrock refinery in 1922. Through successive promotions, he became shift foreman and later assistant superintendent at the company's refinery at Wichita Falls, Texas.

Fenex

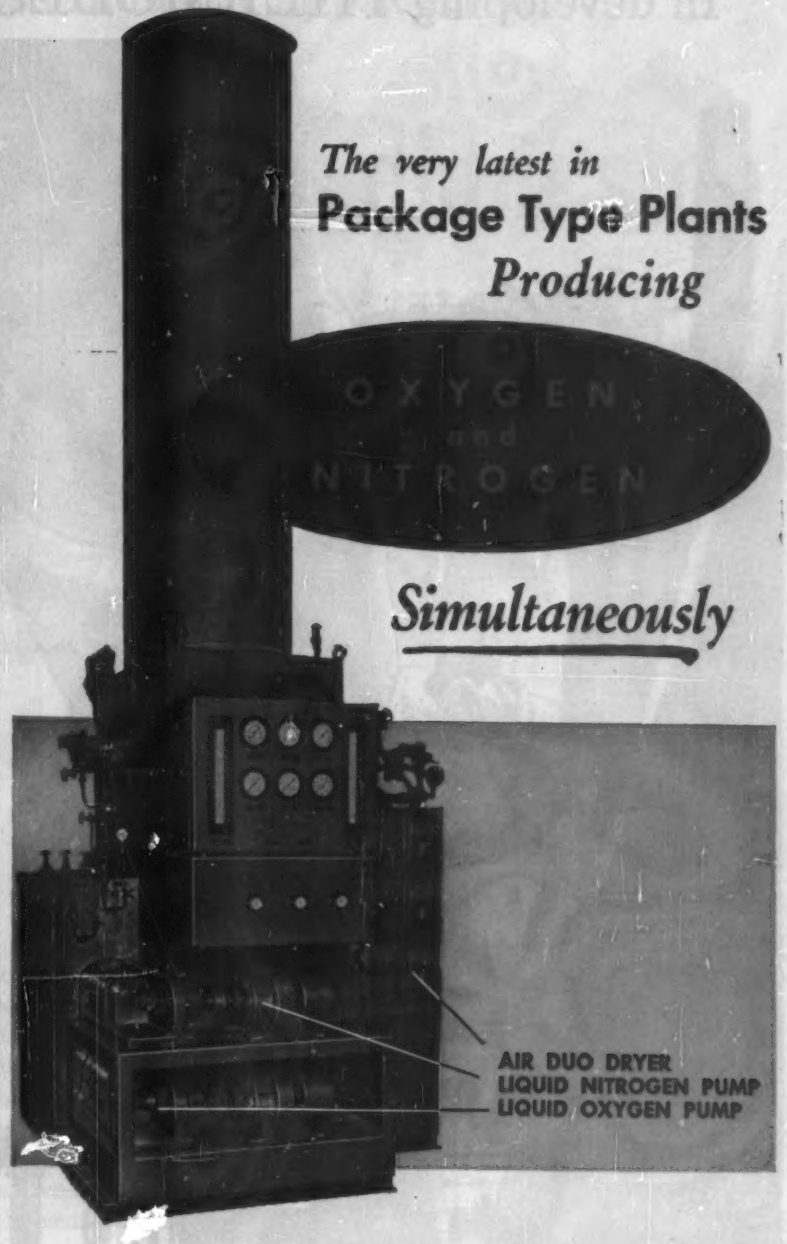
Conoco's Denver refinery was completed in 1931 and Fenex became its first superintendent. In 1940, he transferred to Lake Charles, La., to serve as superintendent of a new company refinery there. He returned to Denver in 1948 as western region refinery superintendent, a title that was changed two years later to manager of manufacturing for the Rocky Mountain region.

Douglas P. Bailey has been named manager of the Purchasing department of The Texas Co., with headquarters in New York. He was previously manager of the Operations division, Refining department. He joined Texaco in 1927 after receiving a B.S. degree in chemical engineering from the University of Texas.

Bailey succeeds **Howard S. McCray,** who was elected chairman of the board of directors and chief executive officer of the Texas-Zinc Minerals Corp.

P. J. Merkus, manager of Shell Oil Co.'s Wilmington, Calif., refinery, has been named manager of the firm's Wood River, Ill., refinery. He succeeds **H. D. Dale,** who is retiring.

Merkus joined Shell in 1934 as a technologist. He has served at the Norco, La.,



With the introduction of our latest, improved design Package Type Generating Plants, production of high purity Oxygen and Nitrogen simultaneously *increases* production 60% over the production of Oxygen alone, *plus* a corresponding reduction in the *cost* of manufacture. Due to its compact design, a minimum of floor space is required and streamlined panel assembly insures instant visibility of all control gauges. Stock sizes from 1500 to 10,000 cu. ft. per hour. Larger and smaller sizes available. 99.99% Argon available on large size plants.

We invite your inquiry.

INDEPENDENT ENGINEERING COMPANY, Inc.

Manufacturers of

CONSULTING IECO DESIGNING RESEARCH

CYLINDERS AND GAS PRODUCING EQUIPMENT
ACETYLENE - OXYGEN - NITROGEN - ARGON

For more data on advertised products, use Readers' Service Cards, last page.

In developing THERMOBESTOS Insulation

J-M at

Low Conductivity. The low thermal conductivity of Thermobestos is best demonstrated in actual service where it makes possible accurate, uniform temperature control, helps reduce fuel costs and contributes materially to operating efficiency.

Not damaged by water. Thermobestos has the moisture resistance outdoor service demands. Soak it in water for one day or 365—and you can still walk on it without damage. Dry it out and Thermobestos is as good as new, with conductivity and structural strength unimpaired.

Johns-Manville

for outdoor process industry applications

research scientists didn't stop top insulating effectiveness...

They added the three physical properties you most wanted— HIGH STRENGTH—LIGHT WEIGHT —MOISTURE RESISTANCE!

Thermobestos® offers the lowest k factor of all insulations in general use throughout the process industries. For maximum heat control on outdoor piping and equipment operating at temperatures to 1200F it just can't be beat!

Yet top insulating effectiveness is only one reason why more and more engineers are specifying Thermobestos for refineries, chemical plants, and wherever hot outdoor vessels and piping must be insulated. For Thermobestos also offers a threefold bonus . . .

. . . Three outstanding physical properties

Thermobestos is 1) strong and rigid. Its hard composition resists crushing and easily withstands unusual service abuse. Yet it is 2) lightweight for easy handling and fast application. And it is 3) highly moisture resistant, remains undamaged even by prolonged wetting.

Quickly, easily applied

Thermobestos is made from hydrous calcium silicate . . . molded to size for proper fit. Its high strength makes it particularly adaptable for time-saving shop prefabrication of fittings and bends.

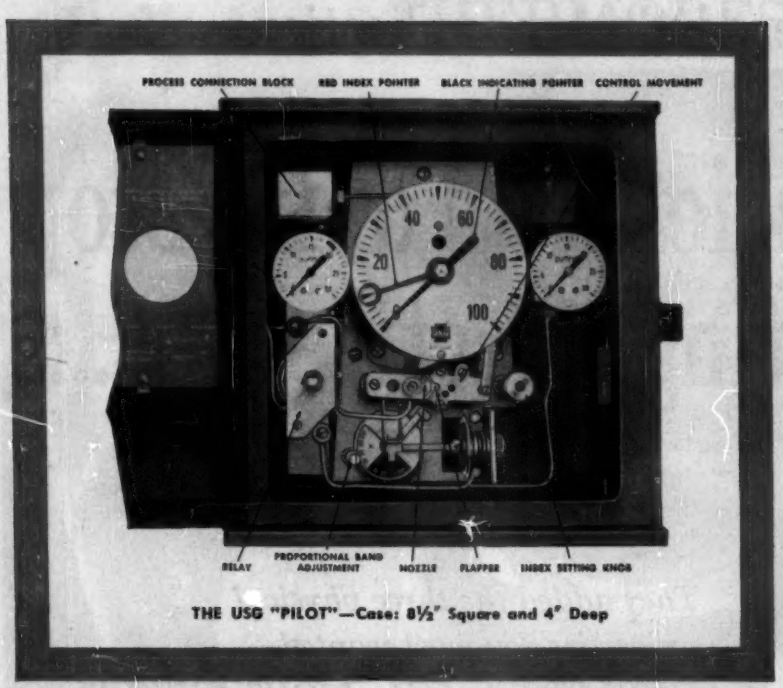
Furnished in large sections, Thermobestos is easy to apply. It reduces the number of joints. In pipe insulation form, it comes in a complete selection of sizes up to 30″ O. D. Also available in 6″ x 36″ and 12″ x 36″ blocks in a full range of thicknesses.

For further information write for your free copy of the 12-page Thermobestos booklet, IN-169A. Address Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

INSULATIONS FOR LASTING THERMAL EFFICIENCY
MATERIALS · ENGINEERING · APPLICATION

JOHNS-MANVILLE JM PRODUCTS

For more data on advertised products, use Readers' Service Cards, last page.



THE USG "PILOT"—Case: 8½" Square and 4" Deep

A COMPACT, LOW-COST*

INDICATING PNEUMATIC CONTROLLER

for pressure . . . temperature . . . other variables

(1) Control modes to suit your process: Two-position with differential gap (1 to 100%) . . . proportional (1 to 150%), alone or with automatic reset or rate action. Control mode or control action (direct or reverse) easily altered in field.

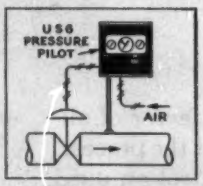
(2) Variable and set point both indicated on large dial: Black pointer indicates reading on 3½-inch dial (6¾-inch scale length). Red circle-tipped pointer spots location of set point.

(3) High accuracy and sensitivity at low cost: Accuracy of 1% of range over middle half of scale. Sensitivity less than 0.1% of scale at 100% proportional band setting . . . compares favorably with higher-priced controllers.

(4) Simplified maintenance and repair: Precalibrated measuring element can be removed for range change. Other basic components, even entire control chassis, can be removed for easy maintenance.

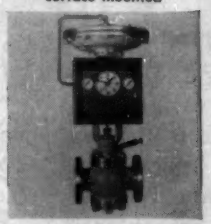
(5) Controls a broad range of variables: Pressures from 30" Hg vacuum to 10,000 psi. Temperatures from —350 F to + 1000 F. Can be adapted to control many other variables, including liquid level.

**Sample price: $126.00 for unit with 316 S.S. Bourdon tube, range 0-600 psi, proportional control 1-100%.*



Typical pressure reducing service

Can be panel or surface mounted



Can be valve mounted

Find Your Nearest Distributor in The 'Yellow Pages'

Write for Catalog 510 . . . Gives complete specifications and description of the USG Pilot as well as pneumatic transmitters and receivers for process instrumentation. Send for your copy today, or contact your nearest USG distributor.

UNITED STATES GAUGE

DIVISION OF AMERICAN MACHINE AND METALS, INC., SELLERSVILLE, PA.

USG

Men in the Industry . . .

refinery as technological department head, and as manager of research and development and assistant to the vice president of manufacturing in New York. He was appointed manager at Wilmington in 1953.

G. C. **Montgomery,** formerly superintendent of the Wilmington refinery, will become manager there. **J. B. St. Clair,** formerly assistant superintendent of the Martinez, Calif., refinery, moves to Wilmington to succeed Montgomery. **E. A. Ballman** succeeds St. Clair at Martinez. He was assistant manager of the Shellburn refinery of Shell Oil Co. of Canada, Ltd.

Jimenez

Gendron

J. G. Jimenez has been elected a vice president of Tidewater Oil Co. and appointed general manager of the company's eastern division operations. Formerly eastern division marketing manager, he replaces **George F. Getty II,** who was recently elected president. **John W. Gendron,** former administrative assistant to the president in San Francisco, was named assistant eastern division manager.

Jimenez joined Tidewater in 1930 as a tank truck salesman. He received a B.A. degree from the University of Southern California and attended Harvard University Graduate School.

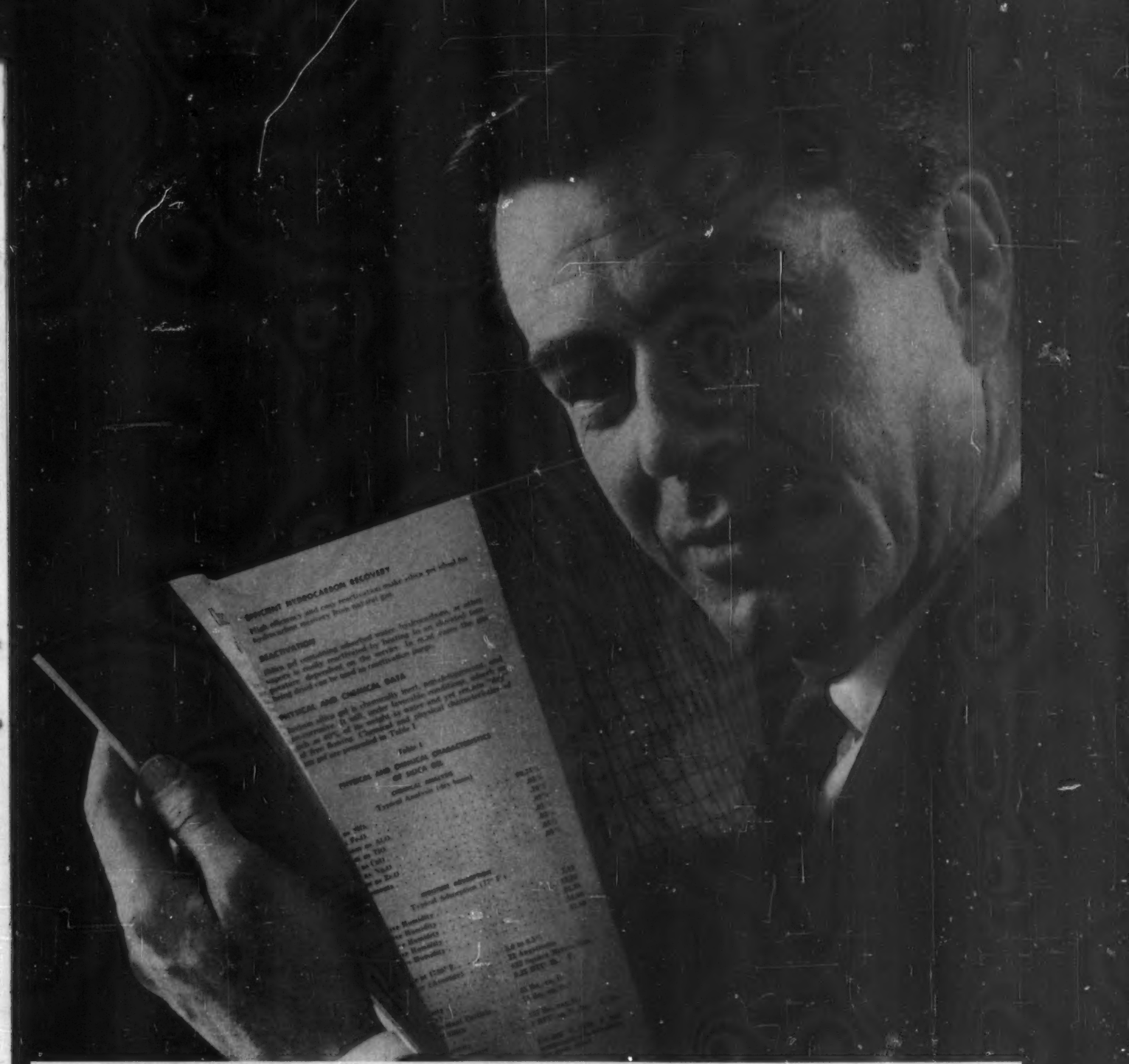
Gendron joined Tidewater as a stock dispatcher in the western division transportation department in 1946. He is currently serving as vice president and director of Tidewater-Iran, Ltd., and as vice president and director of Iricon Agency, Ltd. He was president of Iricon Agency in 1956-1957. A University of Oregon graduate with a B.A. degree, Gendron also attended Georgetown University Law School, the University of San Francisco Law School, and Standford University Graduate School of Business.

Carl M. Furgason, who has a background of 15 years experience in the field of process plant design and construction, has joined the Russell Engineering Corp. in Houston as engineer and office manager. He will devote the majority of his time to design, estimating, and purchasing for the construction of gas and other types of processing plants.

A graduate of the University of Texas with B.S. and M.S. degrees in chemical engineering, Furgason is a registered professional engineer in Texas. He was an instructor in physical chemistry and physics at the University of Texas and worked as a process engineer with the Tennessee Valley Authority in Florence, Ala. Later, he was research project leader at the University on high pressure reenforced plastics.

In 1951 Furgason became associated with Thermal Products Co., Houston, as an engineer. His duties included estimat-

For more data on advertised products, use Readers' Service Cards, last page.



New from Davison...Technical Bulletin 202 on adsorption and dehydration with silica gel

If you have anything at all to do with air and gas dehydration, you'll want this 20-page, well-illustrated technical bulletin.

Here, in text and graph form, is a wealth of valuable, up-to-date technical data on: characteristics of silica gel; fundamentals of adsorption and dehydration; natural gas dehydration; recovery of hydrocarbons from natural gas; compressed air dehydration; atmospheric dehumidification; dehydration of industrial gases; special types of silica gel; and other applications of silica gel. The data presented are based on reliable laboratory and field tests.

We're sure you'll find Technical Bulletin 202 of great assistance in your everyday work. To receive a copy, write to us on company letterhead.

DAVISON
CHEMICAL COMPANY
Division of W. R. Grace & Co.
Baltimore 3, Maryland

PUT READY COOL® IN YOUR *Maintenance Picture!*

Air Conditioning For A Furnace? *Ridiculous!*

Now stop and think a minute. Couldn't you often use a high velocity of cold air to speed cooling of heated vessels? A 60 Ton* entirely portable READY COOL produces 18,000 CFM of air 25 to 30 degrees below ambient temperature even on the hottest summer days at an operating cost of 26¢ per ton/hour.

RESULTS ARE AMAZING!

CASE I One large petrochemical plant in East Texas was dissatisfied with the 70 hours lost in cooling down their cracking heaters for maintenance and repair, and secured a 50 Ton READY COOL. The unit was used as a blower until 600 degrees F. was reached, then the air conditioning was added. There was no brick spalling. The cooling down period was reduced to 20 hours average. Worker efficiency was increased approximately 85% working in 75 degrees instead of 120. ***They reported the heaters were repaired and back on stream in less time than previously required for cooling alone.***

CASE II Another Chemical Plant said their cooling down time was reduced from 48 hours to 8½ using a READY COOL.

CASE III A third Plant stated their payroll was reduced an average of 40% in hot areas where they used their 40 Ton model and that, with less down time, ***it paid out each time they used it.***

FIGURE YOUR OWN SAVINGS

ADD
A. Present cooling down time ____ Hrs.
B. Average work time in Unit ____ Hrs.
TOTAL ____ Hrs.

MULTIPLY
Down—time loss per hour ____ Hrs.
$____ Hrs.

PLUS
C. PAYROLL FOR MAINTENANCE $____ Hrs.
TOTAL COST $____ Hrs.

The Savings with READY COOL will be approximately 60% of this figure. (75% of "A"; 40% of "B" & "C")

* $6,900 FOB New Orleans, La. Patents Pending

READY COOL® INC. PORTABLE ICE AIR CONDITIONERS

2301 American Bank Building
New Orleans, Louisiana

Model	#5820	#5830	#5840	#5850	#5860
Tons of Refrigeration	20	30	40	50	60
C.F.M.	6,000	7,500	12,000	15,000	18,000
BTU Per Hour Capacity	240,000	360,000	480,000	600,000	720,000

All Units Trailer Mounted; Gasoline or Electric Powered

Men in the Industry . . .

ing and contracting installations of industrial thermal insulation as well as investigating industrial applications of reinforced plastics foamed polyurethanes. He specialized in thermal insulation in refinery and chemical plant operations.

Daniel F. Cameron, Ponca City, Okla., chief process engineer in Continental Oil Co.'s Manufacturing department, has been selected from American industry to receive a 1958-59 Sloan Fellowship at the Massachusetts Institute of Technology.

Cameron

Established by the Alfred P. Sloan Foundation, Inc., the Sloan Fellowship Program for Executive Development was founded in 1958 to train promising young technical executives in the broader phases of industrial management, and to prepare them for future positions of business leadership. The course extends from June 1958, to June 1959.

Cameron received his B.S. degree in chemical engineering in 1948 from Rensselaer Polytechnic Institute and his M.S. degree in petroleum engineering in 1951 from the University of Tulsa. He joined Conoco at Ponca City in 1951 as a process engineer in the headquarters manufacturing department and was promoted to senior process engineer in 1955. Be became assistant chief process engineer later that year and chief process engineer in the manufacturing department in 1957.

John J. Winterbottom, who has been transportation coordinator for Standard Oil Co. (N. J.), has been elected a vice president and director of Esso Standard Oil Co. He will be contact director for marine, supply and other activities at Esso.

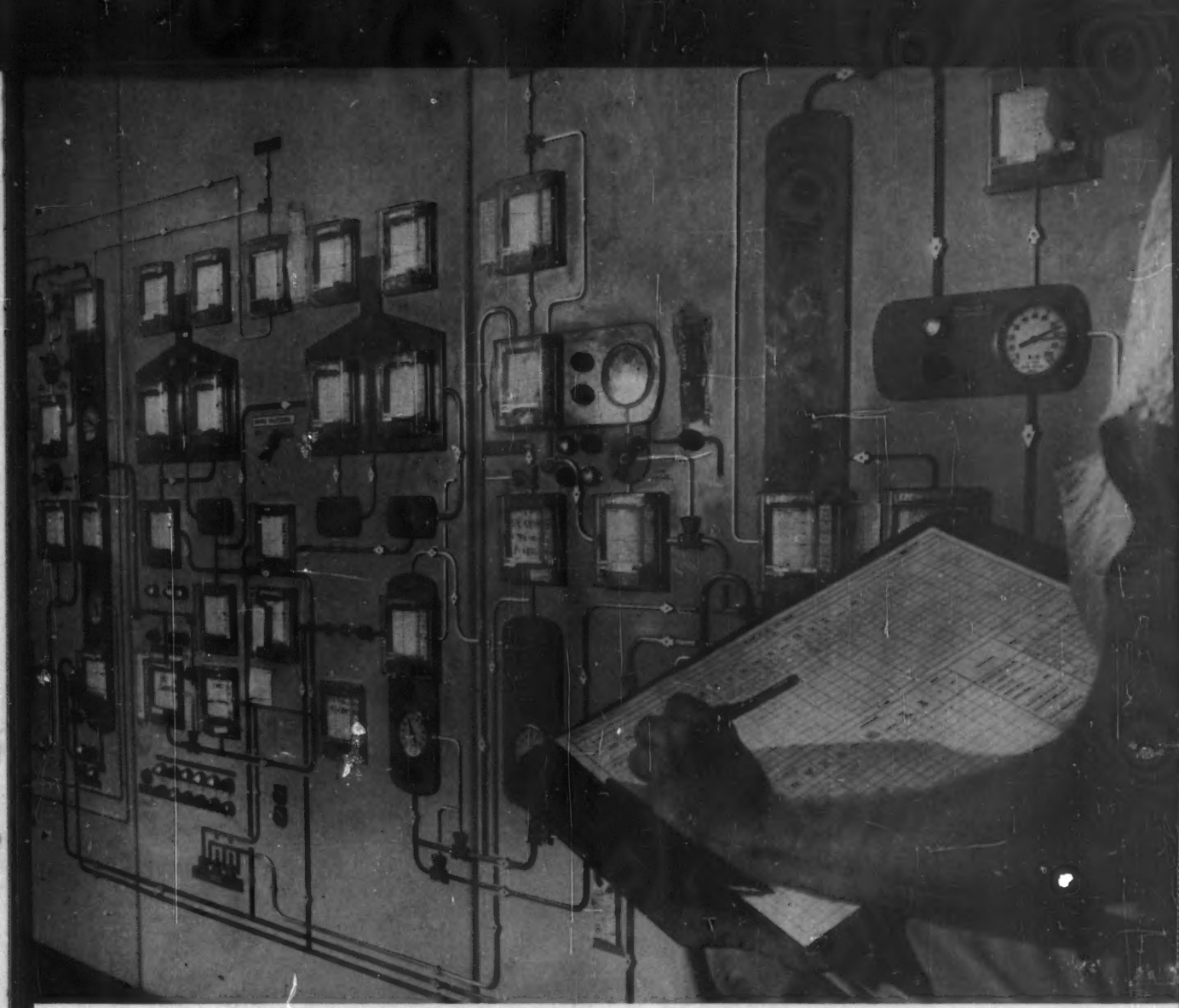
Winterbottom

Winterbottom has been in all phases of marine transportation for 42 years. Since October, 1951, he has headed Jersey Standard's Transportation Coordination department with responsibility for Jersey's world-wide transportation activities.

George C. Merrick has been named manager of industrial relations for Pan American International Oil Co., N. Y. He was formerly employee relations supervisor for Pan American Petroleum Corp., in Tulsa.

In his new assignment, Merrick will be responsible for employee and public relations activities of Pan American International, the recently-formed Eastern hemisphere subsidiary of Pan American Petroleum Corp.

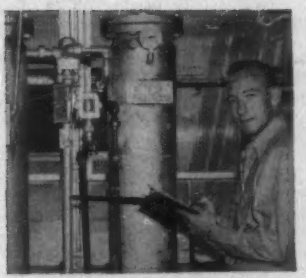
Merrick is a graduate of Yale University. He first joined Pan American in 1940. Following four years of military service from 1941 to 1945, he began a succession



Typical Air-Operated Instrument Panel

To keep down-time down . . .

Come to Kemp



Kemp Oriad Dryer protects compressed air operated control instruments in Seaboard Oil's Powell, Wyoming plant. Dryer, operating 24 hours a day, seven days a week requires only routine maintenance.

A Kemp gas dryer in your operation can put an end to many costly shut-downs by protecting air-operated instruments from corrosion and freezing or jamming . . . efficiently drying inert gases for purging and blanketing . . . or drying atmospheres and process gases in hundreds of other applications. Operations are faster and safer, with better quality control and frequently reduced costs.

And Kemp dryers, operating on the dynamic drying principle, are noted for dependable operation. Rugged Kemp dryers will do your drying job around the clock, month after month, without stoppages or major maintenance. Kemp design reduces utility and operating costs, uses desiccants more efficiently, and eliminates process gas contamination. Units dry to lower dewpoints to give your processes and instruments highest possible protection.

Call your Kemp Representative, listed in the Chemical Engineering Catalog, for detailed information and a no-obligation survey of your dryer needs. Or write direct, for Bulletin D-100. The C. M. Kemp Mfg. Co., 405 E. Oliver St., Baltimore 2, Md.

Kemp Convection Dryers

Kemp Inert Gas Generators

KEMP OF BALTIMORE

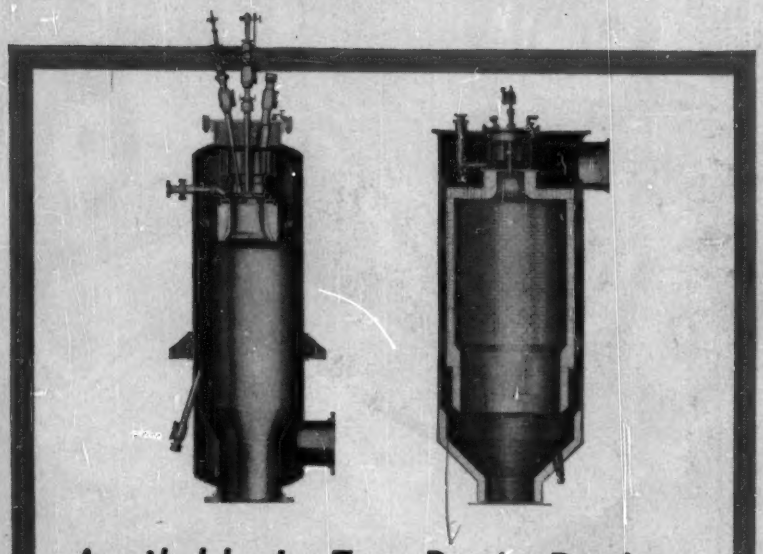
Kemp Industrial Carburetors

Kemp Oriad Dryers

The **PEABODY** Direct-Fired

AIR HEATER FURNACE

For Process Applications



Available In Two Basic Designs

ALL METAL or REFRACTORY LINED

The Peabody Direct-Fired Air Heater Furnace delivers a controlled volume of hot air and combustion gases for gas turbines, spray dryers, kiln dryers, chemical, food or petroleum processes, catalyst regenerators, and flight shape or aircraft component testing facilities.

FUELS—Liquid or gaseous
PRESSURES—One to 10 atmospheres
TEMPERATURES—Up to 3000°F.
INSTALLATION—Vertical or horizontal

For complete information write for bulletin 600A and the name of your nearest Peabody representative.

PEABODY ENGINEERING CORPORATION
232 MADISON AVENUE, NEW YORK 16, N. Y.
OFFICES IN PRINCIPAL CITIES
PEABODY LIMITED • LONDON, S.W. 1, ENGLAND

9-216

Men in the Industry . . .

of assignments in the company's industrial relations department.

In the course of his work, he has served in Oklahoma City, Houston, Brownsville, Texas, and Tulsa. He has been employee relations supervisor in Pan Am's general office in Tulsa since December, 1953. His last previous assignment was as division industrial relations superintendent in Oklahoma City.

Sheets

McCampbell

Arthur J. Good, W. L. Sheets and **H. N. McCampbell** have been named vice-presidents of Stone and Webster Engineering Corp.

Good

After working as a chemical engineer for Sinclair Refining Co., Good joined E. B. Badger & Sons Co. in 1926. He served in various engineering and administrative assignments, including tours of duty in Mexico, Britain and Persia.

From 1953 to 1957, he was managing director of E. B. Badger & Sons, Ltd., the Stone & Webster Engineering subsidiary in London. After returning to the U. S. in May, 1957 he was made comptroller of Stone & Webster Engineering Corp. Good received B.S., M.S. and Ph.D. degrees in chemical engineering from the University of Michigan.

Sheets joined Stone & Webster after 15 years with the U. S. Corps of Engineers and various power and irrigation organizations. As a resident and project engineer for Stone & Webster, he worked on various power plants, transmission lines, and explosive plants designed and built by the Boston firm. From 1943 to 1946, he was resident engineer for Stone & Webster at Oak Ridge, Tenn.

From 1946 to 1955, Sheets was in Los Angeles, Calif., in charge of construction work on power plants and transmission lines for Southern California Edison Co., and other West Coast companies. He was made construction manager in 1955 and transferred to Boston.

McCampbell joined Stone & Webster in 1920 as a field engineer on the construction of industrial and chemical plants and central steam power stations in various parts of the country. During the war years he was assistant general superintendent on the building of the electro-magnetic plant at Oak Ridge, Tenn., and later spent five years as general superintendent on the construction of the power station develop-

For more data on advertised products, use Readers' Service Cards, last page.

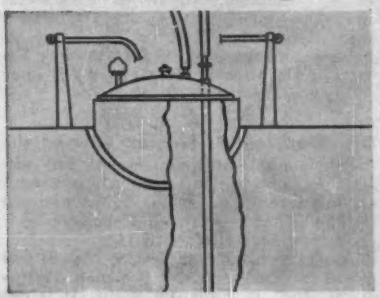
BRIEFS for buyers of

Caustic Soda

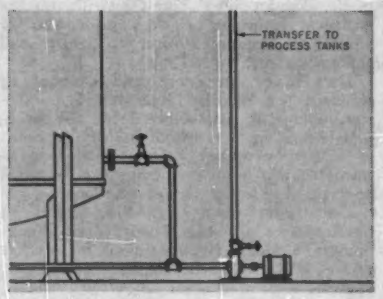
Aluminum Chloride

Chlorine

Caustic soda handling



from tank car



to process

This large subject is covered in *Caustic Soda Engineering and Handling Guide,* a 40-page manual for engineers.

The manual puts at your fingertips the essentials on handling and storing liquid caustic soda, with emphasis on safety, efficiency, and minimum contamination. It includes:

- Detailed diagrams of equipment for unloading, diluting, and storing caustic soda.
- Comonly used methods of unloading tank cars of liquid caustic soda.
- A section on the materials of construction.
- A section on safety precautions and first aid.
- Graphs and tables covering such properties as dilution temperature, vapor pressure, viscosity, and specific heat.

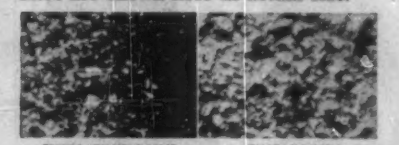
For a copy, check the coupon for Bulletin 102.

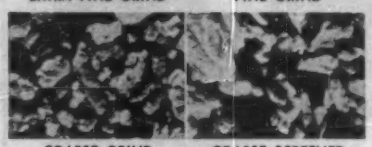
Catalyst Control

with 4 sizes of aluminum chloride

If you're using anhydrous aluminum chloride as a catalyst, you know how important the matter of particle size can be.

Here's a way you can get a choice of *four* standard particle sizes, selected to give you close control of catalyst feed rate, reaction rate, or both. All four sizes are shown here in actual size.





If it's a high degree of reactivity you want, try our *extra fine grind,* 90 to 95% of which passes through a 40-mesh screen.

For slightly less chemical reactivity, *fine grind* (practically all through 20-mesh) is recommended.

Larger in particle is the *coarse grind.* This is 1 mesh and finer with 25 to 35% passing 20-mesh.

For continuous screw-conveyor feeding, you'll do well to purchase the non-clogging *course screened.* This is the same as *coarse grind,* except that it's screened to remove particles 20-mesh and finer.

You can get this high-purity product in pails weighing 50 lbs. net, and in removable-head steel drums, 100 and 500 lbs. net. For further data, check the coupon.

Wall chart

helps you handle chlorine safely

A useful adjunct to your plant safety program is this new Hooker chlorine wall chart.

It can help prevent accidents by showing your employees the most important do's and don't's for handling chlorine. In concise, easily understood language, it explains the operation of tank car, ton container, and cylinder valves; describes safe storage methods; and tells what to do in an emergency.

If you'd like a copy of the chart for posting, ask your Hooker salesman or check the coupon.

For more information on chemicals discussed above, check here:

- ☐ Caustic Soda data sheet
- ☐ Aluminum Chloride, anhydrous, data sheet
- ☐ Chlorine Booklet, Engineering and Handling Information
- ☐ Caustic Soda Booklet, Engineering and Handling Guide
- ☐ Chlorine Safety Wall Chart

Clip and mail to us with your name, title and company address. *(When requesting samples, please use business letterhead.)*

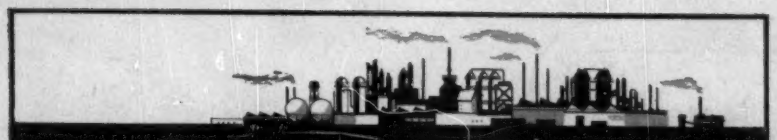
HOOKER ELECTROCHEMICAL COMPANY

1606 FORTY-SEVENTH STREET, NIAGARA FALLS, N. Y.

Sales Offices: Chicago Los Angeles New York Niagara Falls Philadelphia Tacoma Worcester, Mass.

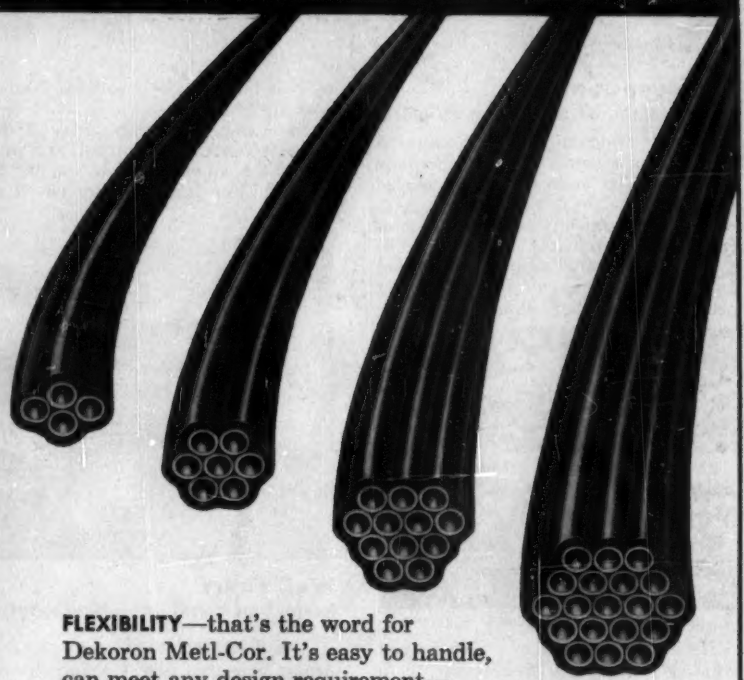
In Canada: Hooker Chemicals Limited, North Vancouver, B. C.

HOOKER CHEMICALS PLASTICS



DEKORON METL-COR
MULTIPLE TUBE HARNESS

cuts installation costs
bends without distortion
solves instrument line corrosion problems



FLEXIBILITY—that's the word for Dekoron Metl-Cor. It's easy to handle, can meet any design requirement—and it's highly corrosion resistant, too.

FIRST, Metl-Cor's exclusive Extru-Loc construction makes it easy to bend with no tube distortion.

SECOND, the Metl-Cor design is flexible. You can specify Metl-Cor with core tubes in either copper or aluminum . . . in any standard or special OD or wall thickness . . . with almost any number of tubes in each bundle.

MOST IMPORTANT, no matter which type or size you specify—you get all the inherent cost-cutting savings and longer life that you pay for.

AA-7511

Dekoron Tubing is available in many other forms: Dekoron Poly-Cor; M-Ribbon; P-Ribbon; Protecto-Pac; Armored Poly-Cor and Metl-Cor; and single-line Dekoron Tubing.

Dekoron® products
QUALITY · RESEARCH · SERVICE

SAMUEL MOORE & COMPANY
DEKORON PRODUCTS DIVISION • MANTUA, OHIO

Men in the Industry . . .

ment at Oswego, N. Y., for the Niagara Mohawk Power Corp.

Since 1953, when he was made construction manager, he has directed building activities for steam stations, boiler plants, manufacturing facilities and the portable atomic power reactor for the U. S. Army.

Dr. Lawrence A. Kimpton and **F. Cushing Smith** have been elected directors by the board of Standard Oil Co. (Indiana).

The election was effective March 4 for Dr. Kimpton, chancellor of the University of Chicago, who replaces the late **Judson F. Stone.** Smith, general manager of the company's supply & transportation department, will replace Dr. Wilson who retired March 19.

Stone, manager of the McCormick Estates and a director of Standard Oil since 1937, died February 20.

Dr. Maurice F. Hasler received the fourth annual Beckman Award for outstanding contribution to the field of chemical instrumentation at the 133rd national meeting of the American Chemical Society in San Francisco, April 14.

Administered by the ACS, the $1,000 award is sponsored by Beckman Instruments, Inc., of Fullerton, Calif. It is designed to honor pioneering achievement in the development of new instruments for chemical analysis or the application of analytical instrumentation to chemical process control.

Dr. Hasler, president and director of research for Applied Research Laboratories, Glendale, was selected for the Beckman Award as a result of his development of a direct-reading optical emission spectrometer which gives a complete chemical analysis of a metal in one minute.

Dr. Hasler earned his B.S. degree in physics at California Institute of Technology in 1929. He continued his studies at Cal Tech to earn his M.S. and Ph.D. degrees, also in physics.

Norman Stein has been appointed group leader at Standard Oil Co.'s Whiting, Ind., Research Laboratories. He joined Standard in 1952 and most recently has been engaged in design work on new processes to make chemicals from petroleum. In his new position, he will direct pilot-plant development of such processes.

Stein received his B.S. and M.S. degrees from the University of Wisconsin, and is a member of the American Institute of Chemical Engineers.

R. E. Clarke has been elected president of Pacific Oil Co. (California), a subsidiary of Standard Oil Co. of California, with headquarters in San Francisco. He succeeds **T. J. Galbraith** who retired March 1. In addition to his new job, Clarke will continue as manager of natural gas utilization.

P. C. Barbosa and C. J. Griffin, both veteran oil men in Latin America, have been elected vice presidents of Esso Standard de Brasil, Inc., marketing affiliate for Standard Oil Co., (N.J.)

Barbosa, who has held various sales positions with the Brazilian company for 27 years, became its sales manager in 1944

For more data on advertised products, use Readers' Service Cards, last page.

Reduce Vapor Losses

WITH

OCECO SERIES V-150

Pilot Operated RELIEF VALVES

For Cone Roof and Other Low Pressure Tanks

They Pay for Themselves By Saving the Vapors Other Valves Waste

Conceived and developed by Oceco engineers, Oceco Series V-150 pilot operated pressure and vacuum relief valves reduce tank breathing to the minimum—and increase product savings to the maximum — that the pressure and vacuum characteristics of the tank will permit.

These new valves do not open until the pressure in the tank reaches the pressure setting of the pilot, or the vacuum in the tank reaches the vacuum setting of the valve. This is unlike conventional valves which start to open at low pressure, so as to build up to full rated flow, within the safe operating pressure of the tank; and thus permit substantial amounts of vapors — and product — to be vented from the tank — and lost — at less than the tank's safe working pressure. Records of Oceco V-150 valves in service, on tanks, prove that they pay for themselves in 7 to 8 months, by saving the vapors that other valves waste.

As shown in the illustration, the system consists of a valve mounted on a tank, connected through a 3" diameter aluminum tube to the pilot, which is also mounted on the tank. Pressure in the tank is applied against the **bottom** of the pilot valve — and through the tube to the large area on **top** the resilient membrane—keeping it tightly seated and preventing any "simmering" or "leakage" at less than set pressure.

The pilot, being very sensitive, opens full the instant the tank pressure reaches its set pressure, evacuating vapors from the top of the membrane, which opens instantly to **full flow** position, releasing tank pressure. The pilot closes automatically when the pressure in the tank has been released, reseating the valve membrane tightly again and shutting off the flow. Furnished in 6", 8", 10" and 12" sizes with low pressure (½ Oz. to 8 Oz.) or high pressure (½ Lb. to 15 Lb.) pilots, and with either open or closed type valve housings.

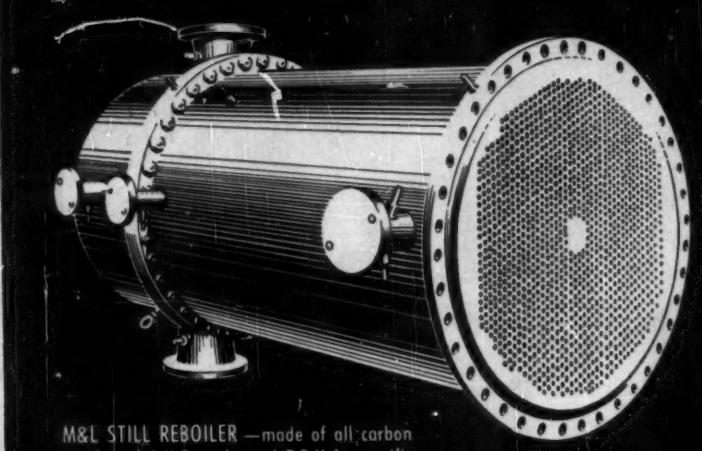
Get full details. Write for Bulletin No. 581 Today!

THE JOHNSTON & JENNINGS CO.

4700 West Division Street • Chicago 51, Illinois

***Division of* PETTIBONE MULLIKEN CORPORATION**

MANNING & LEWIS



M&L STILL REBOILER —made of all carbon steel to A.S.M.E. code and T.E.M.A. specifications. (Design temp. 450°F, weight 9500 lbs., Shell—44" dia., 8'9" length, 1-1/16" thick, 1500 steel tubes—¾" O.D. x 14 B.W.G.)

Many years of experience have given us an unusually thorough knowledge of the appropriateness, adaptability and qualities of fabrication of a wide variety of metals. This accumulated knowledge, coupled with our engineering experience and the important "extras" in fabrication, is your assurance of practical trouble-free equipment at the lowest possible cost.

It is impossible, in a field requiring such wide diversification, to illustrate, or even list all the products we have been called upon to supply. An excellent case in point, however, is the Reboiler above. In its fabrication, X-Raying was performed to assure perfect welds. This example is typical of the "extra" care you can expect and get from Manning & Lewis.

Call on us the next time you need equipment. We are fully qualified to design and fabricate to all codes.

M&L MANNING & LEWIS

ENGINEERING COMPANY

Dept. C, 28-42 Ogden Street, Newark, New Jersey

DESIGNERS & MANUFACTURERS OF QUALITY HEAT EXCHANGE EQUIPMENT

Men in the Industry . . .

and was elected to its board of directors in 1950. He is a petroleum geology graduate of the University of Pittsburgh.

Griffin, a director of Esso Standard Oil, S.A. in Havana, since 1956, has worked for Jersey Standard affiliates in the Caribbean area for 24 years. After 15 years with the Lago Oil & Transport Co., Ltd., refinery at Aruba, he transferred to Essosa's Belot refinery as superintendent in 1951. He entered marketing at Havana in 1953 and three years later became division manager.

Robert E. Tucker has assumed new duties as purchasing agent for Pan American International Oil Co., N.Y. Formerly division purchasing agent in the Canadian division office of Pan American Petroleum Corp., Tucker will be in charge of purchasing for Pan American Petroleum's recently-formed Eastern hemisphere subsidiary. He has been with Pan American since 1940, following studies in business administration at Oklahoma State University. He worked in producing, clerical and accounting positions until 1950, when he was appointed a buyer in the Central division office at Oklahoma City. He was made division purchasing agent at Calgary on November 1, 1954.

Nathan J. Clark, chief accountant for Shell Chemical Corp.'s chemical sales division, has been named treasury manager for Shell Oil Co.'s Honolulu division. He will go to Hawaii early in April.

Clark began his career with Shell Oil Co. in 1946, as a statistical clerk in the Baltimore office. In 1949, he moved to head office, N. Y., as an accountant in the controller's organization. He transferred to Shell Chemical Corp. in 1955, and was named chief accountant in 1956.

Salvadore P. Lio will become assistant to the general manager of Monsanto Chemical Co.'s Overseas division at St. Louis, effective June 1.

Lio, appointed to the Plastics division's development department early this year, joined Monsanto in 1942 as a research engineer with the Plastics division. He held supervisory positions in the production department at Springfield and served a year in Brazil on plastics production problems. He served as manager of the Monsanto Mexicana S. A. plant at Mexico City for several years prior to rejoining the Plastics division in 1956. Lio has a B.S. degree in chemical engineering from Pennsylvania State University.

L. Edward Tinnell has been promoted to purchasing agent and manager of the general service department of the Lion Oil division. He has been with Lion since 1934.

Arthur Q. Svoboda has been appointed product supervisor, industrial phosphates, for the Inorganic Chemicals division. He has been a member of the division's sales department since 1956.

Lloyd H. Todd has been appointed manager of the engineering department, Plastics Division plant, Texas City, after serving as assistant manager since 1957.

J. Kenneth Craver has been appointed manager of organic products development for the Research and Engineering division. He was head of the applied exploratory research group there since 1956.

H. Harold Bible, vice president and

How you can be sure to get the capacity you pay for in a cooling tower...

Thousands of gallons of water pour through a cooling tower every minute. If it goes in hot and comes out cold . . . if it keeps a plant's process water reasonably cool—is it safe to assume that the tower is doing its job . . . that the owner is getting his money's worth out of it?

Definitely not!

A tower may actually be operating at only a portion of the capacity paid for—without the owner's knowledge. Its heat transfer efficiency may fall short of specifications. Operating horsepower requirements may be higher than they should be.

How can you tell?

By conducting thorough field performance tests. But if the tower proves deficient, you can correct it only by increasing horsepower or the size of the tower—or both. Even though the manufacturer stands behind his product, you are put to additional expense, you may lose valuable production because of down time during the reconstruction, and your operating power costs may be increased for the entire life of the tower.

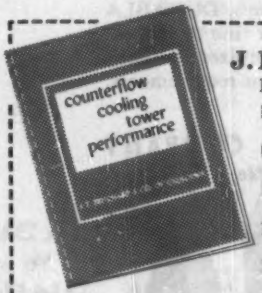
Obviously, the best thing is to *know* the capacity before you buy.

How? Well, you *can* accept the manufacturer's guarantee. But how many manufacturers *really* know? Determining the capability of a cooling tower is an exacting science, requiring highly specialized knowledge of a wide variety of factors influencing performance.

Portions of such knowledge have been published in the past but much has been retained by cooling tower manufacturers as "private and confidential" data. But now, Pritchard has gathered all this information, refined it, added to it field-tested findings from our own research facilities, and arranged it into usable form. This reservoir of knowledge has been published under the title, "Counterflow Cooling Tower Performance," and is available from Pritchard for $3.00. For your copy, mail the coupon below with your check or money order.

No book alone, however, can guarantee cooling tower capacity. That is the responsibility of experienced Pritchard engineers, who translate the information contained in the handbook into cooling tower designs that give you performance, not promises . . . real long-run economy, not first-cost-only economy.

The result is that when you buy from Pritchard, you buy with full confidence that you get what you pay for. You can rest assured that your Pritchard tower will deliver the capacity you specify.



J. F. PRITCHARD & CO. OF CALIFORNIA

Dept. 102, 4625 Roanoke Parkway, Kansas City 12, Mo.

- ☐ Enclosed is $3.00. Please send copy of "Counterflow Cooling Tower Performance"
- ☐ Please send free copy of new Counterflow Cooling Tower Bulletin 4.9.080A
- ☐ Please have your representative call on me

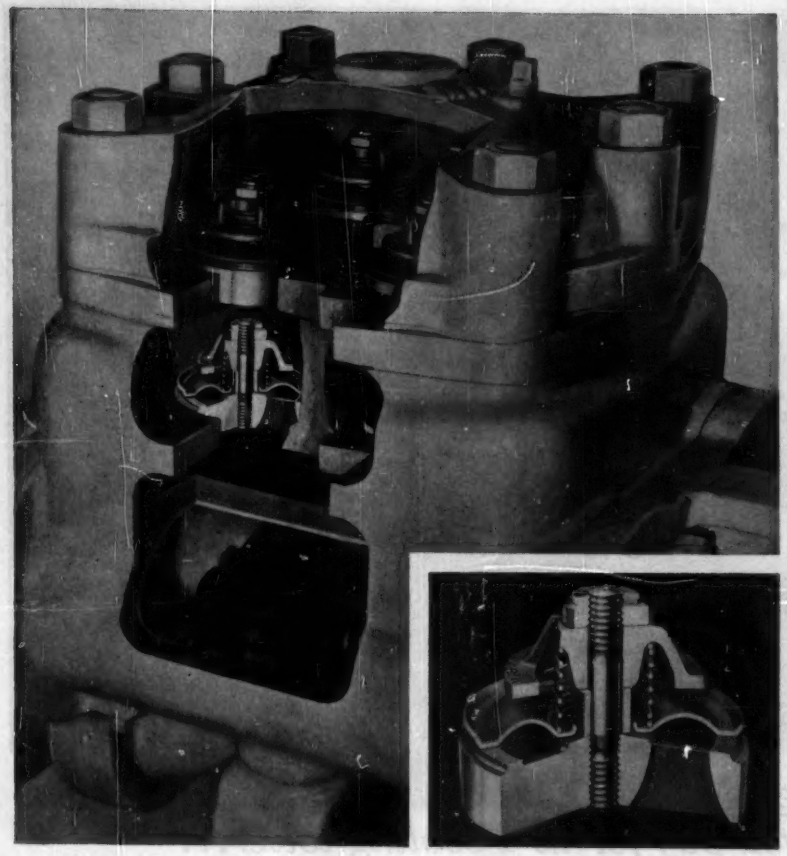
Name..... Title.....

Firm.....

Address.....

City..... Zone..... State.....

For more data on advertised products, use Readers' Service Cards, last page.



The valve for reciprocating pumps . . . old or new

Because they offer a happy combination of dependability, efficiency and extra life, DURABLA Valves are a credit to any reciprocating pump. Mechanically and metallurgically speaking, they will operate freely under temperature-pressure extremes, with highly corrosive fluids and in any position.

In a DURABLA Valve Unit, only "point contact" is made by the valve member on the sleeve, so it can't bind or hang-up. Due to its unique arched design, neither will it warp. The new V-7* taper-locked stud can be screwed down tight into the seat without any possibility of galling or breakage. And a self-locking nut and "drop-on" guard assure quick and easy inspection of working parts —without stud or seat removal.

Standard equipment on many new pumps, DURABLA Valve Units are also used throughout the world to re-valve older pumps. They come in fifteen sizes, designed to meet over 300 variations in installation requirements.

Write for new booklet PR68.

DURABLA MANUFACTURING COMPANY
114 Liberty Street, New York 6, New York

DURABLA®

DM-34

Men in the Industry . . .

assistant general manager of the Lion Oil division, has been elected a Monsanto vice president and general manager of Lion.

John L. Gillis and **T. M. Martin**, both vice presidents and directors of Monsanto, have been elected to the company's executive committee.

Dr. David T. Mowry has been appointed director of development for the Research and Engineering division here after serving as its director since 1957.

Irving C. Smith has been elected vice president of Monsanto. He was controller and director of the Accounting department.

Daniel L. Hussey has been appointed deputy manager of the new refinery now being built in Cologne, West Germany, by Esso A. G., Standard Oil Co. (New Jersey) affiliate.

Hussey, former general superintendent of Esso Standard Oil Co.'s Bayway, N. J., refinery, and more recently general manager of the Abadan refinery in Iran has assumed his new duties.

Hussey became general superintendent of the Bayway refinery in January, 1953. Later he was named general manager of the Abadan, Iran refinery. Returning to this country in mid-1955, Hussey was appointed assistant general manager of Esso's East Coast manufacturing division.

Leon B. Shore, Stephen L. Wythe and Harlan M. Smith have been named section heads in the Products Research division, Esso Research and Engineering Co.

Shore, who has been with the company since 1953, joined the products research division soon after he received a Ph.D. in chemical engineering from the University of Delaware. His B.S. degree in the same field was earned at Drexel Institute in Philadelphia. Dr. Shore's work has been mainly on gasoline additives and basic research in combustion problems.

Dr. Wythe, who has been with Esso Research since 1953, has Ph.D., M.S. and B.S. degrees, all in organic chemistry, from Columbia University in New York City. Dr. Wythe's work primarily has concerned additives for lubricating oils.

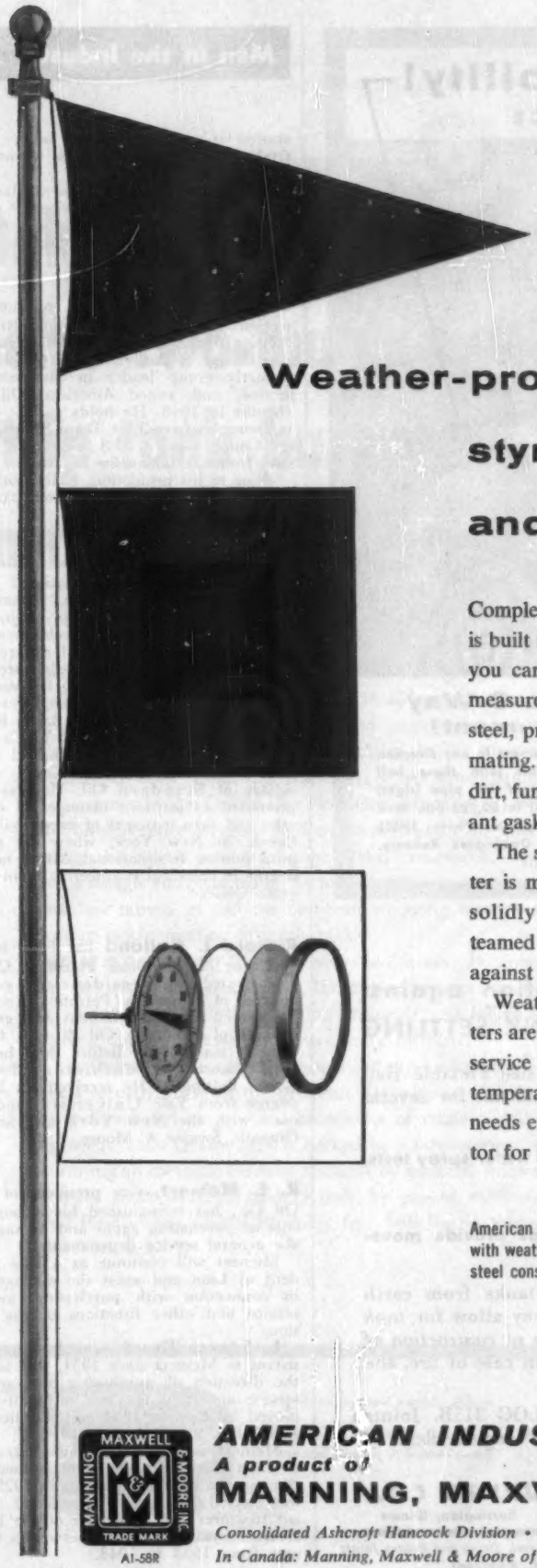
Dr. Smith has been with the Linden research firm since 1949. He joined the company soon after he received a Ph.D. in physical chemistry from the University of Chicago. His B.S. degree from Carroll College in Waukesha, Wis., is in chemistry. His work has covered a number of areas including industrial lubricants.

I. J. Satterfield has joined Humble Oil & Refining Co.'s Research and Development division, and **J. E. Spell** has returned from military service to the Technical Service division at the company's Baytown refinery.

Satterfield holds a B.S. degree in chemistry from University of North Carolina and a Ph.D. degree from Texas University. Spell has a B.S. degree in chemical engineering from Texas A & M College.

John W. Ogden has been appointed manager, Chemical Plants department of Foster Wheeler Corp. Ogden, formerly manager of sales, Chemical department, came to Foster Wheeler upon graduation from Lehigh University in 1930. He

For more data on advertised products, use Readers' Service Cards, last page.



Weather-proof construction stymies erosion and corrosion

Complete protection against erosion and corrosion is built into American Bi-Metal Thermometers, so you can always be sure of accurate temperature measurement. Both case and bezel are stainless steel, precisely fitted and gasketed to insure snug mating. Whatever the weather, rain, sand, dust, dirt, fumes and frost are sealed out by a heat-resistant gasket between case and thick cover glass.

The stem of the American Bi-Metal Thermometer is mirror-smooth stainless steel. All joints are solidly welded. Top resistance to corrosion is teamed with strength, rigidity and tight closure against process pressures.

Weather-proof American Bi-Metal Thermometers are noted for high sustained accuracy and long service life. There are mounting styles, dial sizes, temperature ranges and stem lengths to meet your needs exactly. Ask your industrial supply distributor for help in proper selection.

American Bi-Metal Thermometer with weather-proof stainless steel construction.

MAXWELL MM& MANNING & MOORE INC. TRADE MARK

A1-58R

AMERICAN INDUSTRIAL THERMOMETERS

A product of

MANNING, MAXWELL & MOORE, INC.

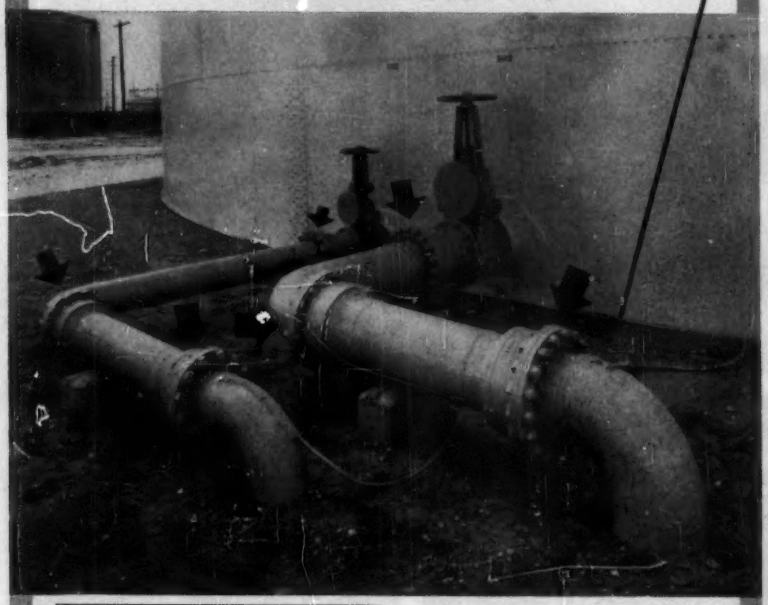
Consolidated Ashcroft Hancock Division • Stratford, Connecticut

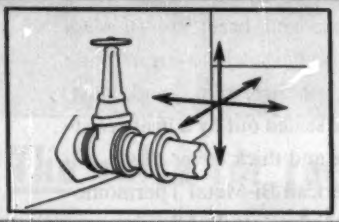
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

For more data on advertised products, use Readers' Service Cards, last page.

Unlimited Flexibility!

—PROVEN IN SERVICE





Allows 6-Way Movement!

Freedom of movement in any direction is readily possible with these *ball joint connections* of 12" pipe (right) and 8" pipe (left) to 80,203 bbl. tank shown in above photo. (Photo: SHELL OIL COMPANY, Dominguez Refinery, Wilmington, Calif.)

Barco Ball Joints—

provide complete protection against

FIRE, EARTH SHOCK, TANK SETTLING

The rapidly increasing use of Barco's new large size Flexible Ball Joints in California, and other locations, is significant for several key reasons:

1. **Fire-Safe. The joints have passed rigid fire and water spray tests.**
2. **Unlimited flexibility and movement.**
3. **Long service life without maintenance.**
4. **Joints insulate against electrolysis as well as provide movement in all planes.**

Such installations protect piping, valves, and tanks from earth movements, shifts, shocks, and earthquakes. They allow for *tank settling* or *tilting* as well as for *thermal expansion* or *contraction of piping* leading to tanks without creating strain. In case of fire, the joints are "fire safe."

For detailed information, WRITE FOR CATALOG 215B. Joints available in steel with flanged or welding ends. 15° angular flex.

PRODUCTS BACKED BY EXPERIENCE
BARCO
ANNIVERSARY 1900 50TH 1950

BARCO MANUFACTURING CO.
5426 Hough Street • Barrington, Illinois

The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Rotary Joints
In Canada: The Holden Co., Ltd., Montreal

Men in the Industry . . .

started as a design engineer in the Industrial department before his transfer to sales.

As Manager of the Chemical Plants department, Ogden will supervise the design, engineering and construction of chemical plants for the production of basic chemicals.

Joe T. Kelly has been promoted to section head, petroleum section, Research division of the Research and Development department of American Oil Co. He was formerly group leader in the petroleum section, and joined American Oil as a chemist in 1948. He holds a B.A. degree in chemistry from East Texas State Teachers College and a M.S. degree in chemistry from the University of Texas.

Prior to his promotion, Kelly worked in hydrocarbon conversion research and fuel and lube development work.

John W. Miller has been appointed general manager of International Refineries, Inc.'s Wrenshall, Minn., refinery. He began his career as a design engineer in 1934 with Standard Oil Development Co., Bayway, N. J. After several different assignments in the Bayway, Baltimore, Md. and Everett, Mass. plants, he was promoted to process control engineer with Standard Oil Co. of La. at Baton Rouge. In 1947 he was transferred to Caripito, Venezuela where he was technical supervisor for Creole Petroleum Corp., a subsidiary of Standard Oil. He was later promoted to assistant manager of export sales and then manager of export sales for Creole in New York, where he served until joining International. Miller holds a degree in chemical engineering from Lafayette College.

Richard I. Galland has been named president of American Petrofina Co. of Texas, and vice president and general counsel of American Petrofina, Inc. He has served as vice president and general counsel of Colorado Oil & Gas Corp., Denver, since 1955. Before that, he was chief counsel for Mathieson Chemical Corp., Baltimore. He received his L.L.B. degree from Yale University, and was once with the New York law firm of Cravath, Swaine & Moore.

R. E. Meinert, vice president of Lion Oil Co., has relinquished his responsibilities as purchasing agent and manager of the general service department.

Meinert will continue as a vice president of Lion and assist the management in connection with purchasing, general service and other functions of the division.

L. Edward Tinnell, who has been assistant to Meinert since 1951, will assume the direction of purchasing and general service activities. He was originally employed by Lion in 1934 and was licensed as a C.P.A. in Arkansas in 1947.

Meinert, who has been a vice president of Lion Oil Co. since 1943, joined the company as purchasing agent in 1929. He was elected assistant secretary and assistant treasurer and a member of the Board of Directors in 1932, and served as treasurer from 1933 to 1943.

For more data on advertised products, use Readers' Service Cards, last page.

Oakite ECP
engineered cleaning program

helps two-man crew strip tank bare in matter of hours

Rust spotted, oil-splotched and peeling, an oil storage tank cried out for repainting. But stripping the old paint and soil had previously taken many tedious—and costly—man-hours of wire brush work. When refinery called in the Oakite engineer, he drew up an ECP, including a recommendation to strip tanks by the Oakite Hot Flow-On method. A heated solution of Oakite Stripper M-3 was flowed onto the tank surface through a perforated pipe "rake," recovered in a canvas trough, and recirculated. In just a few hours a painting team had moved in and the two-man stripping crew was ready to tackle another unsightly tank.

WHAT IS OAKITE ECP? It's an *Engineered Cleaning Program* that stresses chemical cleaning. It's engineered specifically for your refinery, for your cleaning problems, and for each cleaning operation—tower by tower, valve by valve.

The Oakite engineer lends personal and experienced supervision to each phase of the program. He supplies detailed instruction based on practical knowledge of refinery cleaning needs. Each Oakite ECP is backed by a *laboratory* concentrating on chemical cleaning research, by *materials* known to make short work of refinery soils, by proved *methods*. Send for booklets. Oakite Products, Inc., 50B Rector Street, New York 6, N. Y.

SPECIALIZED INDUSTRIAL CLEANING
OAKITE
MATERIALS · METHODS · SERVICE
SCIENCE

Export Division Cable Address. Oakite

Technical Service Representatives in Principal Cities of U. S. and Canada

In our 50th year.

Oakite ECP
your economy key

For more data on advertised products, use Readers' Service Cards, last page.

ANNOUNCING

immediate availability as plates and heads

LUKENS

The Strong, Economical Alloy Steel

-320°F.

At as low as half the cost of other materials for low-temperature work, readily available Lukens Nine Nickel is proving its tremendous usefulness for storage and process vessels handling liquid nitrogen and liquid oxygen. It can be furnished in the form of plates and heads in a broad range of sizes.

PRICE: Approximately $0.30 per pound, including heat treatment. Exact prices will be furnished on request.

-320°F.

SPECIFICATIONS: Lukens Nine Nickel is produced to meet ASTM A-353 and A-300 specifications. It is included in the ASME-UPV Pressure Vessel Code, Section VIII, 1956 edition.

-320°F.

PROPERTIES

Minimum tensile strength	90,000 psi.
Minimum yield strength	60,000 psi.
Elongation in 2 inches, minimum, per cent	22.0

Charpy impact tested in accordance with ASTM A-300 Specification down to −320° F.

-320°F.

COMPOSITION

Carbon, maximum, per cent	0.13
Manganese, maximum, per cent	0.80
Nickel, per cent, (approx.)	9.00
Silicon, per cent, (approx.)	0.30
Phosphorous, maximum, per cent	0.035
Sulfur, maximum, per cent	0.040

For dependable service to

-320°F.

NINE NICKEL

for Low Temperature Service

-320°F.

FABRICATION: Normal in accordance with ASME Code. Lukens Nine Nickel has been welded with both manual electrode and inert gas shielded process.

-320°F.

AVAILABILITY: Lukens Nine Nickel is immediately available. The same prompt delivery is assured as with other Lukens alloy steel plates and heads.

HELPING INDUSTRY CHOOSE STEELS THAT FIT THE JOB

MAIL THIS COUPON TODAY!

LUKENS STEEL COMPANY
226 Lukens Building, Coatesville, Pa.
Please send me complete information about Lukens Nine Nickel alloy steel for the following low temperature service: _____

NAME _____ TITLE _____
COMPANY _____
ADDRESS _____
CITY _____ ZONE _____ STATE _____

LUKENS ®

For more data on advertised products, use Readers' Service Cards, last page.

What Suppliers Are Doing . . .

Claus

Carl Claus has been elected a vice president of The Babcock & Wilcox Co. He will continue to direct the activities of the Staff division, which provides essential services to all divisions of the company.

Following graduation from Lehigh University with a B.S. degree in industrial engineering, Claus joined B&W as an apprentice engineer in 1931. He became assistant superintendent of the company's former works in Bayonne, N. J., in 1937. The following year, he was made superintendent of the Refractories division plant in Augusta, Ga. He became executive assistant in charge of Refractories division sales and manufacturing in 1953, and was promoted to director of the Staff division in 1955.

Friedli

Frank L. Friedli has been named assistant sales manager, special projects, for The Cooper-Bessemer Corp., Mount Vernon, Ohio. He will be directly responsible for the sales of automatic controls to the oil, gas, chemical and power industries.

Friedli attended Kansas State College, and during World War II, was a Captain in the Corps of Engineers. After joining Cooper-Bessemer he held the positions of acting manager of application engineering, assistant to director of market research, manager of the Power Sales section and projects manager of the company.

Dany

Elmer W. Dany has been appointed executive vice president and to the board of directors of Patterson Foundry & Machine Co., East Liverpool, Ohio, a Ferro subsidiary. A 31-year veteran of Ferro, Dany is vice president of the corporation, in charge of the Furnace Engineering division, and will continue his duties in that division while assuming his new responsibilities at Patterson. A graduate mechanical engineer of the University of Alabama, he joined Ferro in 1927, was named chief engineer in 1937, and was appointed vice president in 1951.

Craine

James R. Craine has been promoted to branch manager, East Central District of The Cooper-Bessemer Corp., Mount Vernon, Ohio. He will be responsible for all application and sales of engines and compressors in the East Central area, working out of the East Central district office, Mount Vernon.

Craine holds a B.S. degree in industrial engineering from Ohio State University. He was a sales engineer for the Macklin Co., Jackson, Mich., before joining Cooper-Bessemer.

Hyatt

Theron D. Hyatt has been elected treasurer of the Walworth Co. He will report to George E. McDonald, vice president, finance.

Hyatt joined Walworth in 1941 as general credit manager, and served as assistant secretary of Walworth International Co. from 1954 to 1955 at which time this subsidiary was dissolved. In 1955, he was appointed assistant treasurer of Walworth Co.

Prior to joining the company, Hyatt was with Readers Digest Association and the Chappaqua National Bank, Chappaqua, New York.

Jaquith

Elliot F. Jaquith has been named chief engineer for Stone & Webster Engineering Corp.'s newly formed Industrial Projects division. Since 1928 he has been active in the design of various types of industrial plants built by Stone & Webster and E. B. Badger & Sons Co., which merged with Stone & Webster in 1951. From 1953 to 1957 he was assigned as engineering manager to the London office of Stone & Webster's English subsidiary, E. B. Badger & Sons, Ltd., handling projects in the United Kingdom, Europe and the Middle East. Jaquith is a member of the Massachusetts Society of Professional Engineers.

Griesbach

Howard W. Griesbach has been appointed vice president in charge of operations at Flexonics Corp., Maywood, Ill., and has been elected a director of the company. He will head all the company's production and sales activities.

Griesbach joined Flexonics as a plant maintenance employe during summer vacations while attending school. He advanced to the Spinning department when he began full time employment. His rise took him through production, supervision and management, sales, sales management and production administration to his present position. Griesbach attended Elmhurst College and Northwestern University.

Oppenheim

Stanley G. Oppenheim has been named vice president and general manager of the W. S. Rockwell Co., Fairfield, Conn.

Prior to joining the company, Oppenheim was manager of the gauge products division of Norden-Ketay Co., and was previously with the U. S. Gauge Co. A former management consultant, he had served on the War Production Board and as a director of the War Manpower Commission.

Born in Kentucky and educated at the University of Rochester, he taught at the Wharton School of Business of the University of Pennsylvania and at New York University School of Commerce.

Hewson

John E. Hewson has been appointed manager of the New York sales region of The Foxboro Co., Foxboro, Mass., supervising instrument sales activities in New York, Connecticut, and New Jersey. He succeeds E. H. Huckman, who is now assistant field sales manager for Foxboro.

Hewson served as production control engineer for Dow Chemical Co., Freeport, Texas, and as process research engineer for Texas Research Foundation, Renner, Texas. He joined the company in 1949 as an instrument engineer in the Dallas branch, and was later appointed branch manager of the company's Tulsa office.

Jirasek

John V. Jirasek has been appointed manager of Worthington Corp.'s newly created Process Industries department, with headquarters in the Harrison, N. J., Marketing division. Jirasek formerly was sales manager of the Southwestern regional sales organization. He will now be responsible for the corporation's relations with customers in the petroleum, petrochemical and associated industries.

A graduate of the University of Prague, Jirasek joined Worthington in 1940 and has since been concerned chiefly with the

For more data on advertised products, use Readers' Service Cards, last page.

"Take a tip from me—

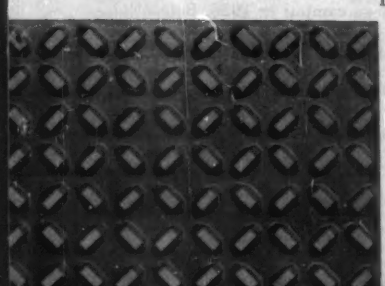
One slip can cost more than USS Multigrip"

USS* Multigrip Floor Plate is specifically designed to help protect you against accidents from slips and skids. It will pay you to look for possible accident-prone areas that could be made safe with Multigrip.* For it provides traction at all times—in all directions.

Where floor surfaces take a pounding, USS Multigrip supplies a rugged, long-lasting cover. It's made from heavy-duty plate that will last for years without maintenance. Studded with hundreds of risers in a symetrically designed pattern, their flat tops provide a greater bearing surface, reducing wear and prolonging the non-skid properties. Rugged though it is, it's comfortable to walk on and safe, wet or dry.

You save money on cleaning, too! A quick once-over with a broom or hose will get it spick and span. There are no pockets to hold dirt. Water drains quickly in any direction. Get USS Multigrip from our local distributor near you or write for more information.

Sold by leading distributors from coast to coast

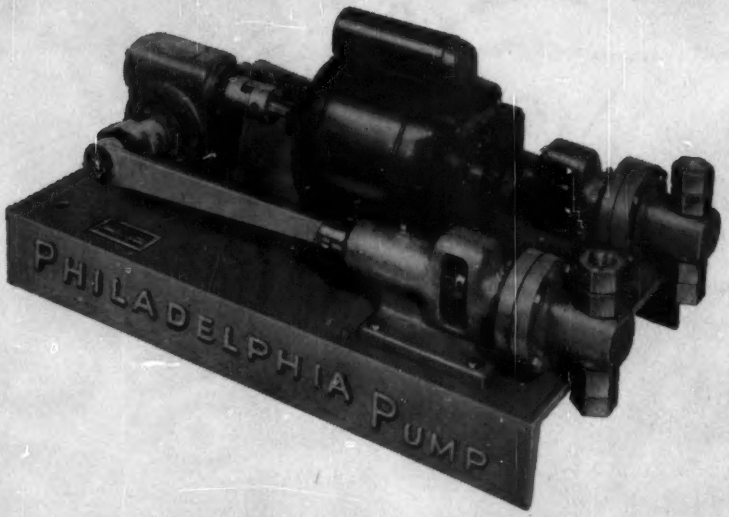


United States Steel Corporation – Pittsburgh
Tennessee Coal & Iron – Fairfield, Alabama
Columbia-Geneva Steel – San Francisco
United States Steel Supply – Steel Service Centers
United States Steel Export Company

USS United States Steel

*TRADEMARK

PHILADELPHIA



controlled capacity

PUMPS

Accuracy and low maintenance to meet fluid proportioning requirements in Chemical Processing, Refining and Boiler Feed Applications.

Philadelphia proportioning pumps feed precisely metered fluids or slurries into low or high pressure systems in nearly any desired ratio with flow, temperature, pressure, conductivity, PH and other controlled process variables. Control may be manual or automatic—with electric, hydraulic or pneumatic systems.

Models may be obtained to handle a great variety of "tough," corrosive and viscous materials. *Write for full information.*

AMERICAN METER COMPANY
PUMP DIVISION

13500 Philmont Avenue, Philadelphia 16, Pennsylvania

High-Pressure Pumps • Controlled Capacity Pumps • Chemical Feed Systems

Suppliers . . .

sale of equipment to the petroleum and chemical industries, serving as special representative and manager of the Petroleum and Chemical Industries division. In 1954 he was appointed Southwest regional sales manager with headquarters in Houston.

CONOFLOW CORP. has appointed **John C. Koch** executive vice president of the company. He joined Conoflow in 1945 following a ten-year association with the Brown Instrument Co. where he specialized in petroleum and chemical sales. In 1948 he was appointed general sales manager for Conoflow, and in 1950 was made vice president in charge of marketing. In 1955 he was promoted to vice president and general manager.

Koch

Active in the field of automation since 1935, Koch is well known in engineering circles through his affiliations with various trade and technical associations. He is a long-time member of the Instrument Society of America, and has held offices and served on committees both on national and local levels. He studied engineering at Rensselaer Polytechnic Institute.

JOHN ZINK CO. has appointed **E. A. Fischer** to the company's engineering staff. He formerly was a sales engineer for 10 years with the J. Arthur Moore Co., exclusive representative for the Zink company in the New York-Philadelphia area.

Fischer

Fischer is a mechanical engineering graduate of the Newark College of Engineering. He is past president of the Technical Sales Society of New Jersey and past treasurer of the Instrument Society of America, New Jersey Section. Last year Fischer spent considerable time conducting experiments on the Zink research and development furnace with engineers from major oil companies.

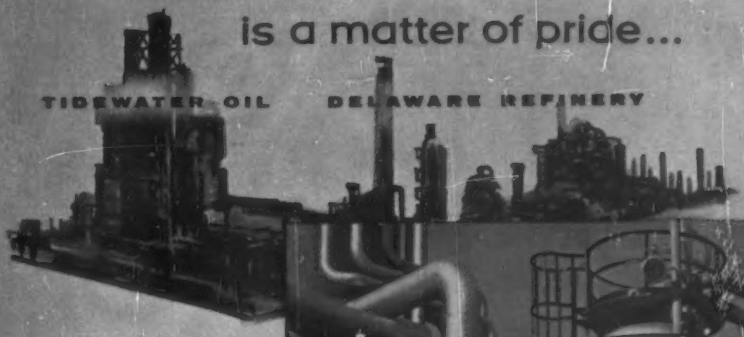
GENERAL ELECTRIC CO. has appointed **Allan I. Benson** manager of scientific applications, one of the eight sections of the General Electric Computer department. He also will continue in his previous position as manager of the computer center, a subsection of scientific applications.

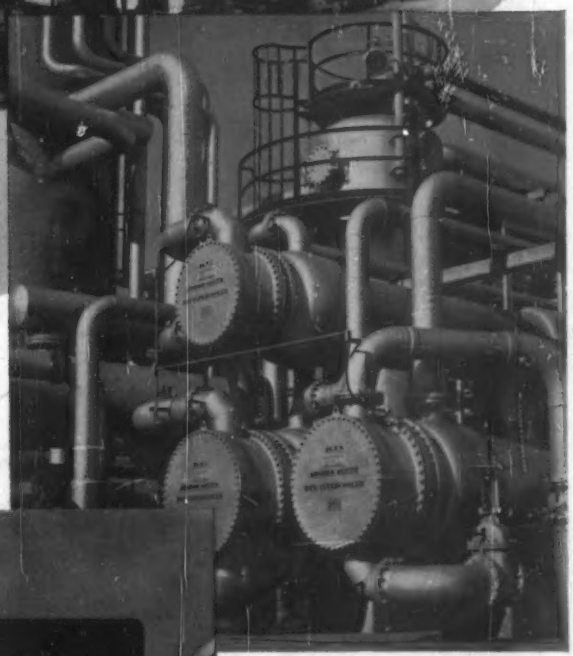
Benson had the responsibility of installing the computer center on the Arizona State College campus in 1956. Before joining the computer department, he managed the installation and operation of a large computer for the aircraft gas turbine division, Lynn, Mass.

From 1949 until coming with General Electric in 1955 he had computer operation duties with the atomic energy com-

For more data on advertised products, use Readers' Service Cards, last page.

where trouble-free performance is a matter of pride...





many heat exchangers are tubed with...

SCOVILL

"the refinery of the future"

HEAT EXCHANGER TUBE

Tidewater Oil Company's showplace installation in DELAWARE, first in a new generation of oil refineries and the largest ever built at one time, also features some of today's finest examples of modern heat exchanger equipment.

The plant was engineered and designed by Tidewater and C. F. Braun & Co., who were also the builders. Selection of Scovill Cupro-Nickel, 30% Heat Exchanger Tube was based on a well-proved formula for trouble-free heat exchanger performance . . . Scovill craftsmanship in tube production plus Scovill Technical Services.

If you are designing, building or operating heat exchangers, it will pay you to discuss trouble-free performance with Scovill.

HEAT EXCHANGER TUBE for Applications from Marine to Petrochemical, from Compressor Intercoolers to "Cat-Cracker" Exchangers, in these popular Alloys . . .
Phosphorized Admiralty • Admiralty • Arsenical Admiralty • Red Brass, 85% • Deoxidized Copper • Arsenical Copper • Cupro-Nickel 10%-20%-30% • Aluminum Brass • Aluminum Bronze, 5% • Muntz Metal • Duplex Tube

MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

Scovill Manufacturing Company, Mill Products Division, 99 Mill Street, Waterbury 20, Connecticut. Phone Plaza 4-1171.

SSCM

Oil gives insects the needle to help farmers bring everybody better foods at lower cost

Yesterday's farmer dropped a seed in the ground—and hoped. Today's farmer increases crop yield and quality with the help of a silent partner: oil.

Take his oil-powered tractor. With its help he can do the work of ten men, ten horses, five hand plows.

Or take insecticides. Last year farm damages by just three insects—the grasshopper, boll weevil and corn borer—totaled almost $300,000,000. Effective insecticides are the biggest reason that this figure—high as it seems—is as low as it is.

And oil research helps. For example, this young lady is testing insecticide formulations. Soon the farmer will have another potent weapon in his pest arsenal.

Simple fact: without the power of oil and the products of oil research, farmers could not adequately feed our country.

The next time you hear somebody who knows little about oil talk against the oil industry, speak up. Tell him the facts, tell him you're an oilman and you're proud of it. And tell him why.

SHELL

SHELL OIL COMPANY

Suppliers . . .

mission's scientific laboratory, Los Alamos, N. Mex. Earlier he served as a physicist at the naval ordnance test station, Inyokern, Calif.

Benson has a B.S. degree in physics from the University of Washington and a M.S. degree in mathematics from the University of Wisconsin.

Daniels

Neely

ROCKWELL MANUFACTURING CO. has appointed **William L. Neely**, assistant controller, and **George E. Daniels**, credit manager, to assistant treasurers. Neely joined Rockwell in 1948 as plant accountant for the company's Oakland, Calif., plant. He was promoted to his most recent position in 1952. He attended Robert Morris School of Business and the University of Pittsburgh and was an accountant with Ernst & Ernst for two years before joining Rockwell.

Daniels joined Rockwell as an accountant in 1949. He was promoted to plant accountant in 1951 and credit manager in 1955. Before joining Rockwell he was accountant office manager with Tarentum Products Corp., a financial analyst with National Tube Co. and an accountant with Westinghouse Electric Corp. He graduated from Robert Morris School of Business.

BORG-WARNER CORP.'S Ingersoll Kalamazoo division has named **John M. Patterson** personnel director. He graduated from Northwestern University in 1949 with a B.B.A. degree. Prior to his appointment, Patterson was staff assistant in management development work, training, and college recruitment for the Borg-Warner central office. Prior to joining Borg-Warner, he was with the Ford Motor Co. and General Motors Corp., Electromotive division.

AMERICAN CYANAMID CO.'S Organic Chemicals division has appointed **R. J. Clay** production manager and **J. Kondrick**, services manager for the Willow Island and Marietta, Ohio, plants. Clay was with Talon, Inc., and the Pennsylvania Rubber Co., before joining Cyanamid in 1949. He has been assistant production manager for the Willow Island-Marietta plants since 1957. He studied at both Carnegie Institute of Technology and Pennsylvania State University.

Kondrick, with Cyanamid for 28 years, joined the company at its Bound Brook, N. J. plant. He has been chief engineer for both plants here since 1955. A graduate of Rutgers University, he is a member of the West Virginia Society of Professional Engineers.

R. E. Leach has been appointed assistant manager for the two plants. He attended Duke University and prior to joining Cyanamid in 1936, was associated with

your choice of tube expander motor controls . . .
for fast, accurate tube rolling
with **ELLIOTT Tube Expanders**

Expanders available in 4 types for tubes ¼ in. through 3 in.

AIR MAGNETIC CONTROL . . .

Excellent for precision tube expanding in hazardous locations. Uses new concept of torque control in tube expanding. Two powerful permanent magnets give instantaneous engagement and disengagement between air motor driver and driven expander. Calibrating dial permits exact settings for torque control.

ELECTRIC CONTROL . . .

Takes guesswork out of tube rolling. A *torque limiting device*, designed for use with any standard tapping motor. A single setting gives same expansion after metal-to-metal contact for entire rolling operation. *Voltage Balancer* eliminates need for voltage regulator. It's compact and easy to operate.

Y7-7

ELLIOTT Company
Lagonda Division, Springfield, Ohio
Headquarters for Tube Cleaners and Expanders

For more data on advertised products, use Readers' Service Cards, last page.

SPECIAL EQUIPMENT for the PROCESS INDUSTRY

AIR HEATERS

Outlet temperatures from 200° to 3000°. Available as a complete unit, or burner unit only. Any required pressure can be met with oil or gas or both as fuels.

INERT GAS GENERATORS

Operating reports on units now in service show perfect CO_2, no excess air, no unburned combustibles, wide turndown, and completely dependable flame stability. Specially engineered to your specifications.

The John Zink line of process equipment also includes the famous JZ Smokeless Field Flare, Waste Disposal Units, and more than 50 gas, oil and combination gas and oil burners. Special burners and process equipment designed for your individual application.

JOHN ZINK
COMPANY
4401 S. PEORIA
TULSA, OKLAHOMA

Suppliers . . .

the Procter & Gamble Co. He was with Cyanamid's Bound Brook, N. J. plant for many years in methods engineering capacities. More recently he has been services manager for the two locations.

THE ROBERT MUDDIMAN CO. has been named distributors of W-K-M ASA through-conduit gate valves. Key Kast and Key refinery fittings. The adding of these products together with the ACF plug valve which the Muddiman Co. is handling for W-K-M now, will offer a complete line of W-K-M valves and fittings for the Canadian industry. The Muddiman Company, with offices in Toronto and Montreal, serves the entire eastern part of Canada.

A new manufacturing plant, organized by W. L. Legro after he acquired the Brinkman Tank Co., Inc., has begun production off Clinton Drive in Houston on heavy equipment for the oilfield, petrochemical, and refinery industries. The new plant reportedly represents an outlay of between $250,000 and $300,000 and is expected to have 50 employes by July.

The plant will be operated by the Port Houston Manufacturing Corp., with Legro as president, Jack Parkin as vice president, and L. R. Allen as shop superintendent.

THE LUBRIZOL CORP. has promoted three executives to new positions. **F. Alex Nason** has been elected vice chairman of the board of directors. One of the founders of Lubrizol in 1928, he was formerly first vice president. **Arthur O. Willey**, vice

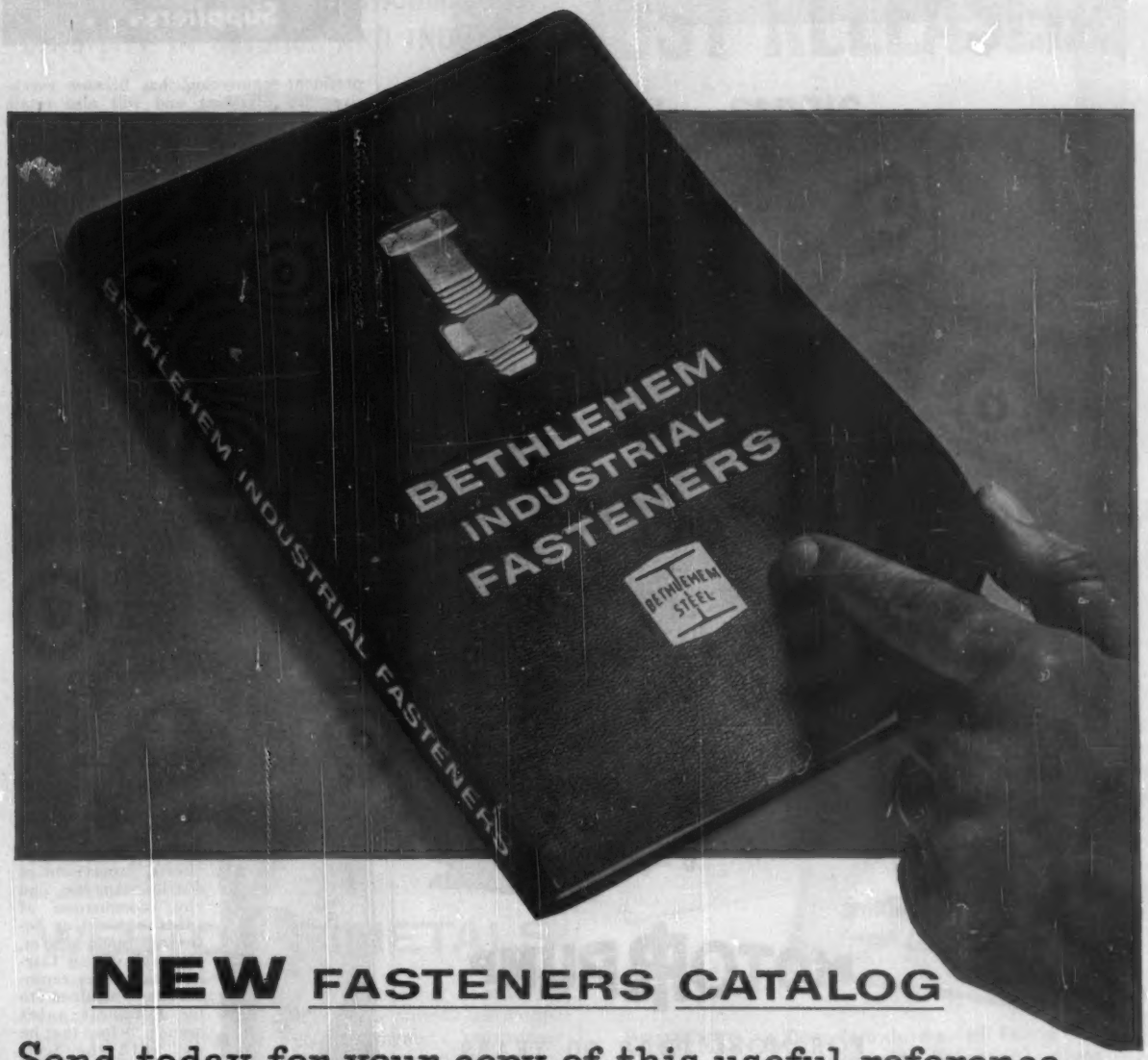
"DELANIUM" GRAPHITE BURST DISCS... FOR RELIABLE LOW-COST PERFORMANCE

After 30,000 cycles at 75% of rated pressure, "Delanium" high-density graphite discs will still fail within the ±5% ASME burst tolerance!

Low-cost, replaceable discs are easily installed in re-usable carbon or aluminum holders. Ratings and sizes stamped on external "ears" are plainly visible, even when installed.

Immediate delivery from stock on standard sizes: 2" to 6"; burst pressure ratings 1 to 100 psig; operating temperatures to 650° F. Other sizes and ratings to order. Write for technical data and price schedule.

KEARNEY INDUSTRIES
DELANIUM GRAPHITE DIVISION
134 Elmora Avenue, Elizabeth, N. J.



NEW FASTENERS CATALOG

Send today for your copy of this useful reference, the most complete edition ever issued!

Bethlehem has just issued "Industrial Fasteners," an illustrated catalog on headed and threaded fasteners. Handsomely bound, this 164-page catalog is attractively printed in two colors; and it is packed with data on just about every type and size of fastener imaginable. List prices, dimensions, weights, and container quantities are also included.

If you have not yet received your copy, use the accompanying coupon. Simply print your name and address, clip the coupon, and mail it direct to us at Bethlehem, Pa.

Publications Department, Room 1037
Bethlehem Steel Company
Bethlehem, Pa.

Gentlemen:
I would like to have a copy of "Industrial Fasteners," your new 164-page catalog (No. 436) on headed and threaded fastener items.

*Name*_____ *Title*_____

*Company*_____

*Address*_____

*City*_____ *Zone*_____ *State*_____

For more data on advertised products, use Readers' Service Cards, last page.

big name
in the
small pump field

Ingersoll-Rand

MOTORPUMP

FOR MORE THAN 90 YEARS Ingersoll-Rand pumps have been demonstrating that highest quality construction means low-cost pumping efficiency.

Modern, compact Motorpumps—designed in a wide range of types and sizes, and *always* available—are meeting requirements in hundreds of varied installations.

Motorpumps will deliver from 5 to 2800 gallons per minute. They operate in any position and save valuable floor space as well. Write today for complete catalog data.

9-825

Ingersoll-Rand

11 Broadway, New York 4, N.Y.

Suppliers . . .

president-engineering, has become executive vice president and will also retain his former responsibilities. **M. Roger Clapp** has been promoted from assistant manager of the company's Manufacturing division to vice president-manufacturing. This position was held by **Clyde H. Britten** until his recent death. Also announced was the election of **Ray J. Ozmun** as director. He is administrative assistant to the president and the chairman.

THE COOPER BESSEMER CORP. has appointed **Donald T. Koch** sales engineer in the company's east central district office. He will work under the direction of **James R. Craine**, branch manager, and will contact gas transmission companies, and oil and gas processing plants, working out of the east central district office, Mount Vernon, Ohio.

Koch

Koch received a degree in mechanical engineering from Cornell University in 1954 and joined Cooper Bessemer in 1956, where he has been associated with the engine and compressor sales engineering departments at the home office.

THE GARLOCK PACKING CO. has appointed **Thomas L. Denney** general sales manager at Palmyra, New York. He will be charged with the administration, direction, and control of field sales efforts, supervision of district managers, and the coordination of sales activities between branch offices. Denney joined Garlock as a sales representative assigned to the Pittsburgh sales branch. Before that he was with the Scott Paper Co. and the Joseph Horne Co.

Denney

Denney is a graduate of LaFayette College, and he attended the Harvard School of Business Administration. He is a member of the American Management Association.

FLEXONICS CORP. has appointed **Richard S. Ferguson** purchasing agent at Maywood, Ill., succeeding **K. H. Flory**, resigned. In his new position, Ferguson will be located in Flexonics' general office and will be responsible for the procurement for all the company's 8 U. S. Plants and 16 field offices. Ferguson, formerly purchasing agent for Faultless Caster Corp., is a director of the National Association of Purchasing Agents.

DU PONT'S Petroleum Chemicals division has made **W. Samuel Carpenter, 3rd**, assistant general manager of the company's Electrochemicals department. He succeeds **Charles B. McCoy** who has been named general manager of the Elastomer Chemicals department.

Carpenter, a son of Walter S. Carpen-

For more data on advertised products, use Readers' Service Cards, last page.

WESTON THERMOMETERS: STANDARDS OF STABILITY IN SCIENCE AND INDUSTRY

HEAVY DUTY RELIABILITY
is built into these

WESTON BIMETALS

For lasting accuracy, even under punishing conditions, you can depend on Weston heavy duty bimetal thermometers. Exceptionally stable sensitive elements . . . corrosion-proof, pressure-tested stainless steel stems and connection nuts . . . rugged forged brass heads . . . suit these bimetals for the most strenuous service. Accuracy is assured within 1% of full scale range. 20 standard ranges: running from −100° to 1000°F or −100° to 400°C. Standard stem lengths from 2½" to 72".

Model 2221: has a 5" diameter head with 9" scale.

Model 2231: 6" diameter head with 12" scale.

Model 1221: straight form—basically the same as Model 2221, but with scale parallel to stem. Stem can be located in any one of 24 positions around the periphery of the head.

For full information, call your local Weston representative, or write to Weston Instruments, Division of Daystrom, Inc., Newark 12, N. J. *In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 10, Ont. Export: Daystrom Int'l., 100 Empire St., Newark 12, N. J.*

WESTON
A DAYSTROM UNIT
Instruments

JUST RELEASED!

New FARRIS Reference Catalog Simplifies Selection and Sizing of Process SAFETY-RELIEF VALVES

CONTENTS INCLUDE

- Complete data on all Farris Standard and BalanSeal valves for process piping
- Special materials for chemical and low temperature service
- Safety-relief valve accessories
- Sizing formulae and factors
- Sizing factor curves for over pressure and back pressure
- Nozzle capacities for water, air, steam, vapors and gases
- Dimension and weight tables

Your copy of the new Farris process Safety-Relief Valves catalog is available immediately. Write today, requesting Catalog FE-118.

PROGRESS THROUGH HONEST PURPOSE
Farris ENGINEERING CORP.
536 Commercial Avenue, Palisades Park, N.J.
In Texas: 5405 Clinton Drive, Houston 20

AFFILIATES: Farris Flexible Valve Corp. • Farris Pickering Governor Co., Inc. • Farris HydroSeal Corp. • Farris HydroTorque Corp.

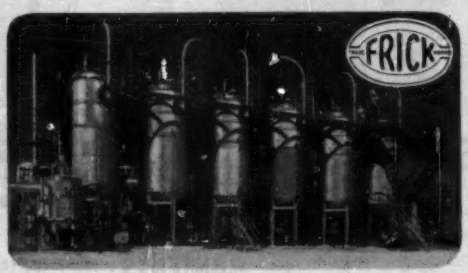
The *Work-Horse* of Mechanical Seals

For the long haul on heavy-duty sealing jobs —specify the engineered mechanical seal with the greatest record of service on processing equipment . . .

FOR FURTHER INFORMATION WRITE FOR CATALOG NO. 480-PR

DURAMETALLIC CORPORATION
KALAMAZOO MICHIGAN

—NEW— GENERAL TIRE AND RUBBER CO. PLANT: Odessa, Texas



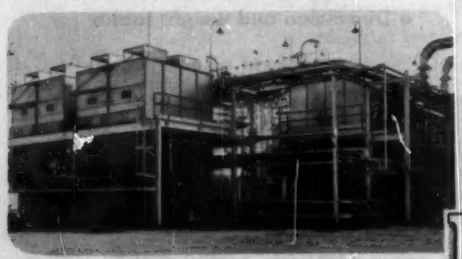
Frick Company furnished the twelve big reactors* illustrated, each 22 ft. high and equipped with a double set of Frick cooling coils*; plus coolers and evaporative condensers for butadiene, evaporative condensers for ammonia, and numerous auxiliaries.

Thus another great synthetic plant joins the list of firms using Frick cooling equipment.

Whatever the refrigerating requirements of YOUR plant—air conditioning, process cooling or condensing, cold water, ice making, quick freezing, cold storage, or low temperatures — Frick engineers will help you design a system to meet your needs.

Call your nearest Frick Branch, Distributor or write to.....

* Patented



Butadiene condensers at Odessa, Texas

DEPENDABLE REFRIGERATION SINCE 1882
FRICK CO.
WAYNESBORO, PENNA., U. S. A.

Suppliers . . .

ter, Jr., chairman of the board of directors of Du Pont, has been with the company for more than 20 years, starting as an industrial engineer at the Chambers works, Deepwater Point, N. J.

Carpenter was transferred to the Organic Chemicals department as assistant director of sales for the Petroleum Chemicals division in 1955, and advanced to director of sales of that division in 1957. In 1938 he graduated from Princeton University, receiving a B.S. degree in chemical engineering.

THE REYNOLDS METALS CO. has opened a service office for the Venezuelan petrolelm industry. **Eugene Prestera**, a petroleum engineer formerly associated with Mene Grande Oil Co. in Venezuela and with Continental Oil Co. in the U. S. heads the new office. He is a native of Bradford, Pa., and a graduate of the University of Pittsburgh.

Prestera

The Reynolds office will offer technical assistance in applications of aluminum. Prestera will be located temporarily in the Hotel del Lago. Specialists from the company's engineering services department will work with the Maracaibo office as needed.

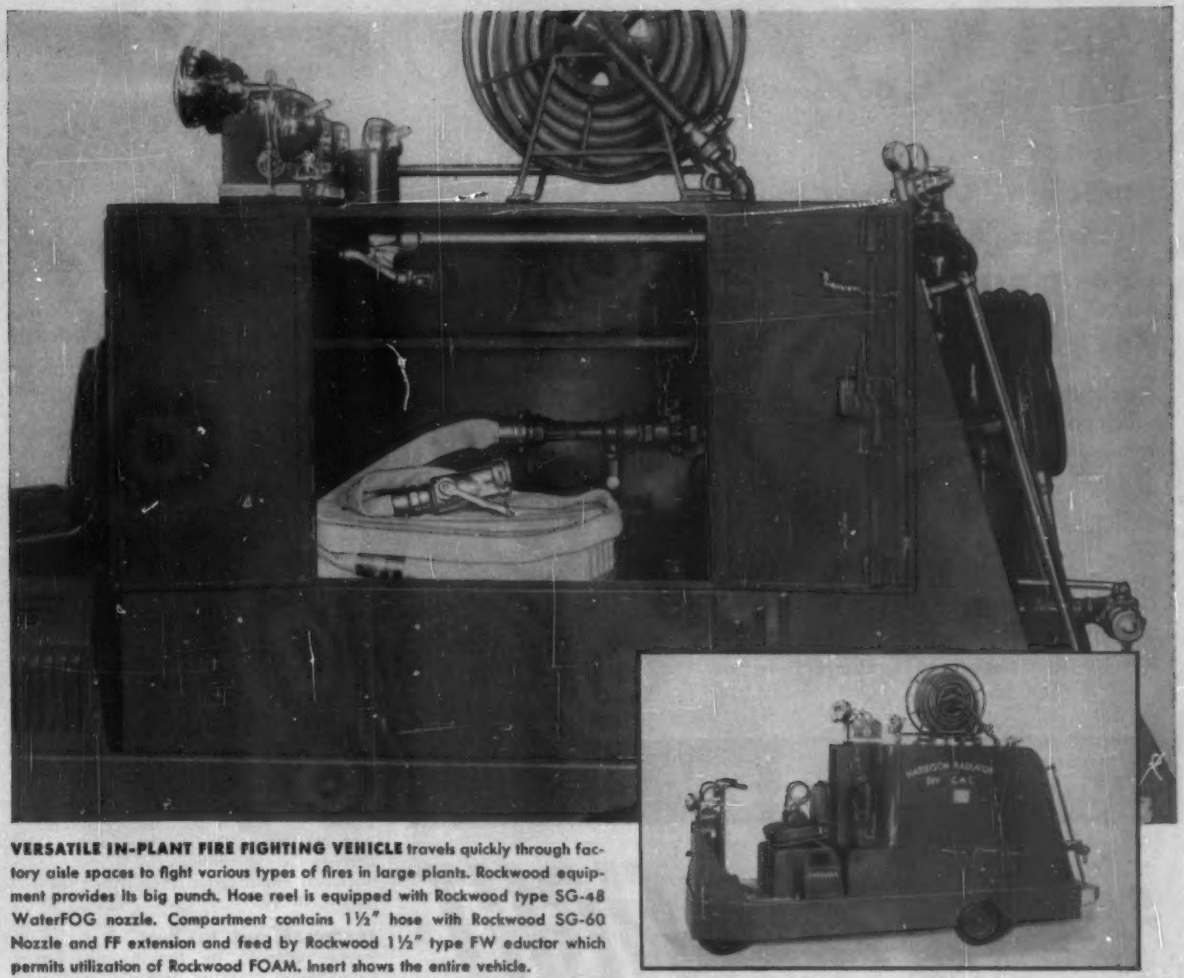
THE SHAFER VALVE CO., Mansfield, Ohio, has appointed **Winslow A. Randle** manager of its Houston office. Prior to his new appointment Randle was a sales engineer for Rockwell Manufacturing Co. for nine years. He has held engineering offices with the A. O. Smith Corp. and the McCarthy Oil & Gas Corp. He holds a B.S. degree in mechanical engineering from Louisiana State University and a M.S. degree in mechanical engineering from the University of Texas.

Randle

MINNEAPOLIS-HONEYWELL REGULATOR CO. has named **Harvey W. Odem** sales manager of the industrial branch office in New Orleans. He will transfer from Wichita, Kan., where he has served as branch industrial manager for the last several years.

Odom joined Honeywell in July 1950 as Valve division sales engineer in the Tulsa branch, later transferring to industrial instrument sales in Wichita. A graduate of Central Missouri State College, he also will direct activities of Honeywell's Baton Rouge office. He formerly was with Atlas Powder Co. and H. W. Snider Co. of Macon, Mo.

SOUTHWESTERN ENGINEERING CO.'S Engineering and Construction division has appointed **Frank W. Crowe** to its sales engineering staff. A chemical enginering graduate of the Carnegie Institute of Technology, he will specialize in services for the chemical, petrochemical, and petroleum



VERSATILE IN-PLANT FIRE FIGHTING VEHICLE travels quickly through factory aisle spaces to fight various types of fires in large plants. Rockwood equipment provides its big punch. Hose reel is equipped with Rockwood type SG-48 WaterFOG nozzle. Compartment contains 1½" hose with Rockwood SG-60 Nozzle and FF extension and feed by Rockwood 1½" type FW eductor which permits utilization of Rockwood FOAM. Insert shows the entire vehicle.

The Inside Story of the Potent "Youngster"—a New In-Plant Fire Fighter

The Young Fire Equipment Corporation of Buffalo, New York, made this vehicle an even more potent fire fighter by installing Rockwood fire prevention equipment.

Here's How It Works

Rockwood FOAM is automatically proportioned (97 parts water to three parts FOAM) and introduced into the hose line by the Rockwood FW eductor. The Rockwood SG-60 WaterFOG nozzle fights fire five ways — by means of a solid water stream high-velocity WaterFOG, low-velocity WaterFOG from applicator, and from FF extension inserted in nozzle, a wide angle FogFOAM pattern and a solid FOAM stream.

Send For Full Information

Rockwood's wide variety of fire fighting equipment is engineered to quickly, safely control fires. Fill in the coupon below now.

Tested and listed by Underwriters' Laboratories, Inc. Distributors in all principal industrial areas.

ROCKWOOD SPRINKLER COMPANY

Engineers Water . . . to Cut Fire Losses

Distributors in all principal industrial areas

ROCKWOOD SPRINKLER COMPANY
Portable Fire Protection Division
2081 Harlow Street
Worcester 5, Mass.

Please send me your illustrated booklet on Rockwood fire fighting products.

Name.....

Title.....

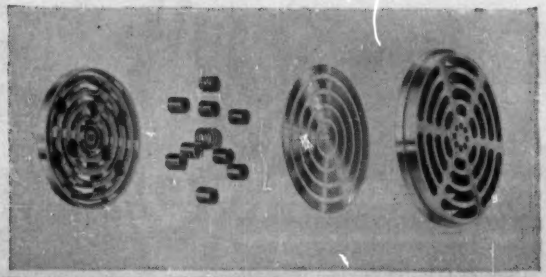
Company.....

Street.....

City.....*Zone*...*State*.....

For more data on advertised products, use Readers' Service Cards, last page.

VOSS VALVES in your machine mean



LESS MAINTENANCE, FEWER SHUTDOWNS for your compressor. (air, gas, ammonia)

- up to 40% more valve area • minimum pressure loss • higher efficiency
- less power consumption • normal discharge temperature
- quiet, vibration-free • utmost safety • lower operating costs

VOSS VALVES are made to specification, machined from solid stock (not cast) — VALVES and PLATES are of heat-treated alloy or stainless steel; PLATES are machined, not stamped, and ground for precise close-tolerance fit; are dimensionally stable . . . ductile . . . resist fracture, high temperatures and corrosion . . . withstand fatigue. SPRINGS, of heavy rectangular sections and large diameters, add to dependability and safety.

Our detailed proposal will be sent without obligation. Send name, bore, stroke and speed of machine.

J. H. H. VOSS VALVES REG. U.S. PAT. OFF.

J. H. H. VOSS Co., Inc.
785 East 144th Street, New York 54, N. Y.

SHUTS OFF—but TIGHT

Proved on gas and steam lines, as well as on lines carrying heavy or viscous liquids, this valve easily closes TIGHT—with absolutely NO LEAKAGE—and just as easily opens for full, unobstructed flow.

After the lever lowers the gate into the closed position, plastic lubricant is forced by means of a screw down through the channels so that the faces of the gate are sealed tight against the valve body. To open the valve, the screw is backed off to relieve lubricant pressure.

That's all. It's rugged, simple, easy to operate, practically fool-proof in even the toughest service. Available in pipe sizes to 2½"; larger sizes available soon.

W. S. ROCKWELL COMPANY
2368 ELIOT STREET • FAIRFIELD, CONN.
Sales Representatives in Principal Cities

Suppliers . . .

refinery industries.

Prior to joining SWECO, Crowe had ten years experience in development and process engineering with C F Braun & Co., Celanese Corp. of America, and Pittsburgh Consolidation Coal Co.

DOVER CORP.'S W. C. Norris Manufacturing division, Tulsa, has appointed **Earl Carpenter**, who has 14 years experience in oilfield supply sales and store management, to its sales staff. He will work in Oklahoma and Kansas, and will headquarter in Tulsa.

UNITED STATES RUBBER CO. has appointed **Dr. Leland M. White** director of research and development, replacing Dr. Sidney M. Caldwell who has retired. Dr. White joined the Research and Development department in 1940 as a research chemist after obtaining his Ph.D. degree in physical chemistry and physics from the University of Kansas. He became research group leader, then department head, and since 1953 has been assistant director of the department.

PITTSBURGH COKE AND CHEMICAL CO.'S Industrial Chemicals division has appointed **Donald L. McCuen** a sales representative to handle industrial chemicals in the Philadelphia territory.

McCuen was formerly a technical representative for Polymer Chemicals division of W. R. Grace & Co., and had been president of his own manufacturing firm, McCuen Products, Inc. He also served as consultant to the Southwestern Research Corp., and was a technical representative with Naugatuck Chemical division of U. S. Rubber Co. He received a B.S. degree in chemical engineering from Princeton University in 1951.

TRACERLAB, INC., has been issued the first license granted by the Atomic Energy Commission covering decontamination operations and storage of waste by-product materials accumulated as a result of any decontamination operation. The license covers all three of the primary Tracerlab locations in Richmond, Calif., Waltham, Mass., and Houston. Tracerlab may, under the provisions of the license, perform decontamination operations in all of the 48 states and D. C.

DU PONT CO. has appointed **W. Allen Taft** director of sales in the company's Petroleum Chemicals division.

Taft started with the company's Explosives department in 1935 as a chemist at the Repauno Works, Gibbstown, N. J., after receiving a B.S. degree in chemical engineering from M.I.T. He has held key positions with the company over the years, and in 1953 was named director of sales in the company's Photo Products department, where he remained until his promotion.

HEYDEN NEWPORT CHEMICAL CORP. has named **Dr. Herman Sokol** executive vice president. He has been vice president in charge of all Heydon research and development since 1954. Dr. Sokol joined Heyden as a research chemist after receiving his Ph.D. degree in organic chemistry from New York University in 1943. While manager of the company's Antibiotics Division, he made a leading contribution to the research team which discovered and developed tetracycline. He has been a director since 1955.

For more data on advertised products, use Readers' Service Cards, last page.

your Aloyco sales engineer has only one business...

stainless steel valves

Your Aloyco sales engineer is a specialist . . . he handles only one line. You, as an Aloyco customer, deal directly with a man who knows his product and its application. He is equipped to get close to your problems and you'll find that this closeness to our customers goes right back to the Aloyco Plants. Doesn't it make sense to depend on the man and the company that specialize in corrosion resistant valves exclusively?

ALOYCO 503 Globe Valve . . . retained bonnet gasket . . . bolted bonnet . . . OS&Y . . . renewable Teflon disc fully retained. The Aloyco Valve line includes a wide range of alloys, types, sizes, and pressures of 150 lb, 300 lb, 600 lb and above. Nuclear Valves up to 2,500 lb.

ALLOY STEEL PRODUCTS COMPANY
Linden, New Jersey

Longer Lasting
ALOYCO
VALVES
1ST IN CORROSIVE SERVICE

A Stearns-Roger produced plant,
large or small, has the finished,
workman-like appearance that says
"here is another quality installation."
Enduring quality . . . .
For the utmost in
design — engineering — fabrication —
field erection — turnkey
operation — take it up with . . .
Stearns-Roger
THE STEARNS-ROGER MFG. CO. • DENVER, COLORADO
DENVER • HOUSTON
EL PASO • SALT LAKE CITY
Stearns-Roger Engineering Co., Ltd., Calgary

Reviewing New Books . . .

Heating, Air-Conditioning

"The Heating Ventilating Air Conditioning Guide 1958", containing a 1272-page Technical Data Section and a 503-page Catalog Data Section, is the 36th and largest annual edition published by the American Society of Heating and Air-Conditioning Engineers.

Revisions and additions include (1) addition of both a description and a design method for high velocity air duct systems, (2) an enlarged section on the heat pump, (3) new information on exhaust hood performance and design for hot and cold processes, (4) a simplified presentation of industrial drying principles, calculations, and system design, (5) extension of data on heavy fuel oils and their use, with preheating, in automatic fuel burning equipment, (6) new data on heat gain through glass block used in skylights, requirements for shading glass, and basic principles involved in calculating heat flow through glass areas, (7) a general revision of the chapter on radiators, convectors, baseboard and finned-tube units and addition of new data on their ratings, and performance, (8) a revision of ranges of capacity for electrical heating units and a method of determining operating cost for these units, (9) an enlarged section on performance and testing of air cleaners, (10) extension of list of allowable concentrations of air contaminants, (11) an increased number of codes and standards of interest to users of "The Guide."

(American Society of Heating and Air Conditioning Engineers, 62 Worth St., New York 13, 1,775 pages, $12.00)

Phase Relations of Gas-Condensate Fluids

This monograph reports many of the important properties of hydrocarbon mixtures. Correlations are given for both 2-component and multi-component mixtures.

The information is derived from a study of mixtures that are pertinent to the recovery of gas and natural-gas liquids from underground reservoirs. However, the correlation of fluid characterics will increase the proficiency of any engineer working with these materials. Complete and detailed examples are given for the solution of a variety of engineering problems to help those who are not familiar with the physical chemistry of hydrocarbons.

(Phase Relations of Gas-Condensate Fluids, C. Kenneth Eilerts et al, American Gas Association, 420 Lexington Ave., N.Y. 17, 439 pages, $10.00. For sale by Gulf Publishing Co., P.O. Box 2608, Houston 1, Texas, U.S.A.)

Company Management

"Developing a Company Management Team" is a stenographic brief of an address given before the California Management Association and the personnel section of The Western Management Association. It describes the obligations and responsibilities to build strong, continuing management teams to implement the technological and scientific advances of today.

(Developing a Company Management Team, David L. Harrington, Management Report 242, Research Division, California Management Association, 2180 Milvia St., Berkeley, Calif., 12 pages, $1.00.)

Emulsions—Theory And Practice

Modern developments in the theory and practice of emulsions are explained in this new monograph. It begins with the facts and theories of surface chemistry and the physical properties of emulsions as a function of composition. Next, the theories of stability and instability (such as inversion, creaming, and complete demulsification) are covered. The volume also contains discussions of the chemistry of emulsifying agents, emulsifier efficiency as a function of composition, and the technique of emulsification, including various types of emulsators.

Two useful appendices deal with the measurement of emulsion properties, and commercially available emulsifying agents.

(Emulsions—Theory and Practice, Paul Becher, Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y., 382 pages, $12.50. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U. S. A.)

Radioisotopes Symposium

This symposium covers testing techniques utilizing radiosotopes and demonstrates the wide range of industrial applications to which they may be put. Changes in physical properties of materials as a result of radiation are discussed

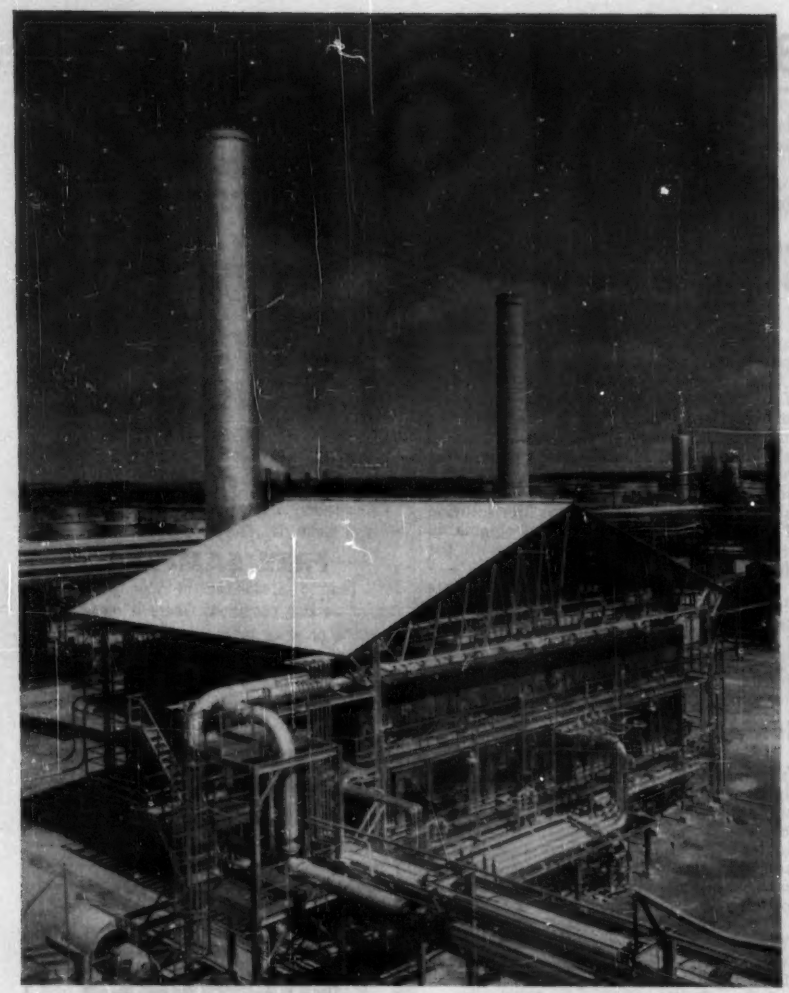
GUNITE
Since 1915
CONCRETE
SAND AND CEMENT
"Placed by Air"
GUNITE
BLO-CRETE WET-CRETE
LINING, ENCASING, FIREPROOFING, REPAIRING
Send for our new bulletin No. 20 of actual photographs, information and detailed specifications.
GUNITE CONCRETE & CONST. CO.
1301 WOODSWETHER RD., KANSAS CITY 5, MO.
2016 W. Walnut St., Chicago 12, Ill.
1004 Market St., St. Louis 1, Mo.
3206 Houston Ave., Houston 9, Texas
1136 W. Orangethorpe, Fullerton, Calif.
Milwaukee—Twin Cities—Denver—New Orleans

REFRACTORY HAYDITE
Makes Higher Heat Resistant Concrete
Haydite aggregate used with Lumnite cement produces refractory concrete suitable for sustained temperatures up to 1800-2000° F., which makes it excellent for tubular heaters, ducts, flues, stacks and catalytic crackers. Weighing from 30 to 40 per cent less than ordinary aggregate concrete, Haydite is exceedingly strong. It has excellent insulating properties and withstands pressures of up to 1130 pounds per square inch. Write today for free folder and complete information about Carter-Waters Refractory Haydite.
We sell direct to you.
CONSTRUCTION MATERIALS
CARTER-WATERS
KANSAS CITY KANSAS & MISSOURI
2440 Pennway Phone GRand 1-2570

IMMEDIATE DELIVERY!
LAMBCO SILKSCREEN STENCIL LACQUERS
Lambco Stencil-Lac has been proved superior by refineries and chemical plants for silk-screening or stencilling tops of barrels and drums.
Made in a full range of colors, Lambco Stencil-Lac is oil and solvent resistant . . . works easily . . . gives full coverage and is extra durable.
Special colors are supplied for individual requirements.
Remember, orders for Lambco Stencil-Lac are shipped same day received.
FREE SAMPLES
Test Lambco Stencil-Lac in your plant under regular working conditions. There is no obligation so phone or write today.
Lambert Corporation manufactures a full line of protective coatings for all purposes and surfaces.
LAMBCO PRODUCTS
LAMBERT CORPORATION
POST OFFICE BOX 151 HOUSTON 1, TEXAS

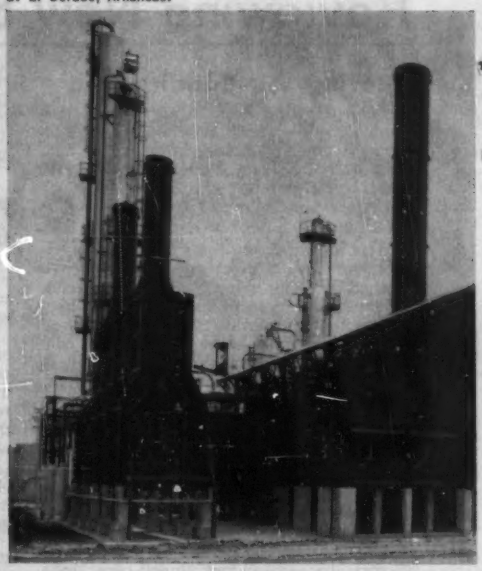
Includes up-to-date, valuable information on more than 140 major—
INDUSTRIAL CHEMICALS

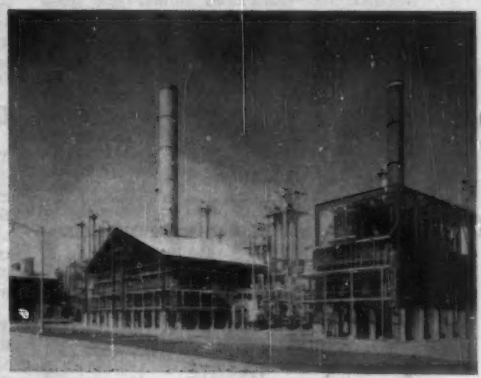
Second Edition
By W. L. Faith, Donald B. Keyes, and Ronald L. Clark. Recognized as the only single volume to list important technical and economic information on the production and use of major industrial chemicals. Now revised to reflect the tremendous changes undergone by the chemical industry since the publication of the first edition, it treats each chemical individually in a separate chapter, supplying information on . . . how it is made . . . how it is used . . . how much has been produced each year for the past 20 years . . . the price range for the past 20 years . . . important chemical and physical properties of the material . . . the usual grades . . . how it is packaged and shipped . . . who makes it and where . . . important economic trends.
1957. 844 pages. $16.00.
Send for a copy today.
For Sale By:
The Gulf Publishing Co.
Box 2608, Houston 1, Texas



Portable crude heater for Magnolia Petroleum Company, Beaumont, Texas.

Ultraformer heater for American Oil Co. at El Dorado, Arkansas.





Platformer and desulphurizer heaters for Shell Oil Co. at Deer Park, Houston, Texas.

HIGHER EFFICIENCY, LUMMUS OIL HEATERS

Lummus designs horizontal and vertical-tube oil heaters to any size, for any process—anywhere in the world.

Major refiners confidently turn to Lummus on their important and difficult oil heater jobs.

In the last 25 years, the combined capacity of all Lummus oil heaters built has exceeded that of any other company in the world. The reasons: greater durability, more efficient operation, an absolute minimum of days lost to downtime.

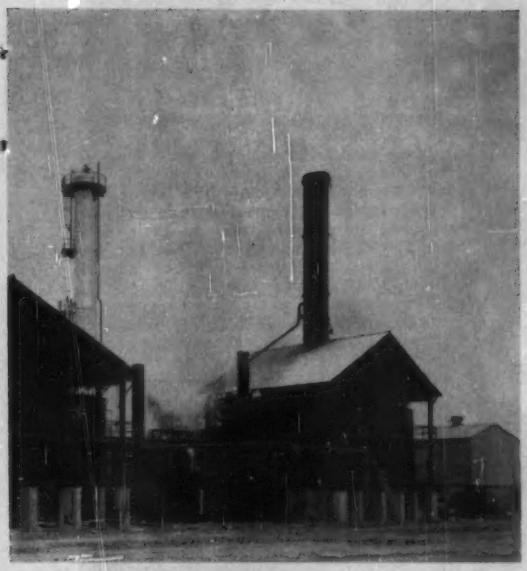
Major refiners maintain large engineering and economics staffs who can evaluate the performance of important heating equipment. They buy more Lummus oil heaters because they *know* through statistical comparison that Lummus gives them *more heater per dollar.*

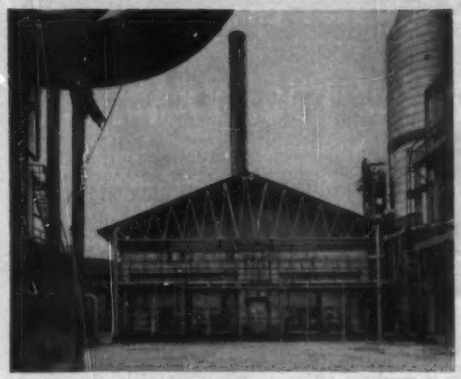
In 1957 alone, Lummus received contracts to engineer more than 130 oil heaters, with a combined absorbed-capacity of over 7,000,000,000 Btu per hour — the largest number of units and highest overall capacity in Lummus' oil heater history!

Lummus offers over a quarter of a century of oil heater experience for petroleum refineries, chemical and petrochemical plants. The highly trained engineering staff of the Oil Heater Division is ready in the Lummus New York office to give each job the full benefit of its accumulated know-how in this field.

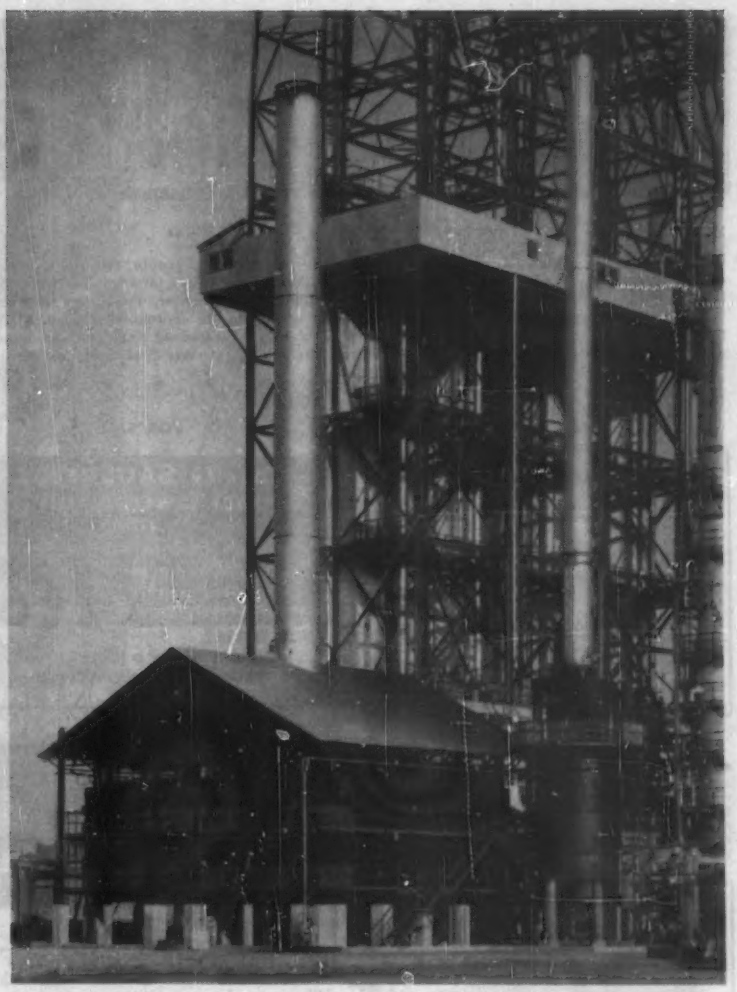
Lummus oil heaters, of both special and standard design, range from 100,000 to 300,000,000 Btu per hour. As illustrated above, neither size, type nor location of the unit presents a problem to Lummus. Because Lummus offers *every* type of oil heater,

For more data on advertised products, use Readers' Service Cards, last page.





Crude heater for Socony Mobil at Paulsboro, N. J.



Delayed coker heater for the American Oil Co. at Yorktown, Virginia.

MINIMUM DOWNTIME MAKE PREFERRED AMONG MAJOR REFINERS

you can be sure that we will recommend the *right* unit for your needs. Complete Lummus facilities are available world-wide through any of the five international Lummus companies. Equipment is designed in New York, procurement is made through the nearest Lummus international office, and the cost of the job is payable in the currency of the country in which the procurement is handled!

Consult with Lummus on your next oil heater — large or small.

LUMMUS

THE LUMMUS COMPANY, OIL HEATER DIVISION
385 MADISON AVENUE, NEW YORK 17, N.Y.

WASHINGTON, D.C. • CHICAGO • HOUSTON • MONTREAL • CARACAS • MARACAIBO • LONDON • PARIS • THE HAGUE

For more data on advertised products, use Readers' Service Cards, last page.

Petroleum Refiner New Classified Rates

RATES: Regular Classified (undisplayed) set in this type: 20 cents per word. Minimum charge, $4. Blind box address in our care counts six words. Replies forwarded without charge. Display Classified ads, set in suitably larger type with ruled border, $12.50 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. All Classified ads payable in advance. Copy deadline: 25th of month preceding date of issue. Send copy and checks to: Classified Advertising, Petroleum Refiner, P. O. Box 2608, Houston, Texas.

* * * * * * * * * * * * * * * * *

HELP WANTED

Petroleum Refinery Engineers

Positions involve technical service and consulting type work for petroleum refiners. Requires chemical engineers with several years experience in refinery process engineering, operations, and/or economic analysis. Positions offer a wide variety of work assignments in an expanding technical activity that works with Sales, Research, Refinery, and company management problems. Also affords opportunity for industry-wide contacts with refining and process companies and for using initiative and individual expression to increase responsibility. Location in Detroit suburb offers ideal professional environment with a choice of city or suburban living. Send resume to:

Personnel Manager
ETHYL CORPORATION
1600 W. 8 Mile Road
Ferndale 20, Detroit, Michigan

POSITION WANTED

• EQUIPMENT INSPECTOR—5 years varied chemical plant and refinery experience currently employed Venezuela desires relocation U.S.A. with progressive company. BSME, married, supervisory experience. For detailed resume write: Box 294-R, PETROLEUM REFINER, Houston, Texas.

MANUFACTURING MANAGER

Currently assistant to Vice President. Broad background in Engineering, Production, Budget, Economics, Construction, and Labor. Graduate Chemical Engineer, age 40, eighteen years in Fine Chemicals, Petrochemicals and Petroleum Products. Box 293-R, PETROLEUM REFINER, Houston, Texas.

FOR SALE

Specify **SAUEREISEN**
ACIDPROOF CEMENTS—COMPOUNDS
FOR
Tanks, Sewers, Stacks, Floors
Technical cements for all purposes.
Send sketches or samples
Sauereisen Cements Company · Pittsburgh 15, Penna.

When you see a large chimney think of Sauereisen Cements.

New Books . . .

in some of the papers. Extensive references and many illustrations may be found in the book.

Among the 11 papers are the following. Autoradiography as a Testing Technique, Refinery Scale Applications of Radioactive Tracers, Activation Analysis for Industry, Thickness, Density, and Concentration Gaging with Radioisotopes, Will ASTM Standards Be Influenced by Radiation Effects in Metals? and The Problem of Establishing Specifications for Irradiated Organic Materials.

(Radioisotopes Symposium, ASTM Headquarters, 1916 Race St., Philadelphia 3, 100 pages, $2.75)

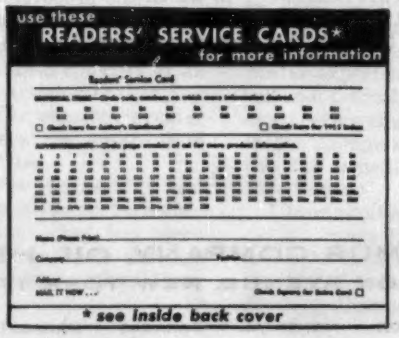
Industrial Relations

In "Outlook for Industrial Relations & Personnel Management," West coast personnel and industrial relations managers speak up on 12 questions put to them in a business outlook survey made among 201 company personnel executives.

The industrial relations men were asked what problem loomed as their most serious challenge in the year ahead? What employment change is expected? Is the personnel budget adequate? To whom are departmental reports made? Are additional staff services planned this year? What about the union contract? Does the company plan some demands of their own this year? What wage and salary increases look probable? What is being done about office unionization attempts in your company or industry?

The report includes current salary rates paid to top personnel officers, second ranking department managers and first assistants in industrial relations in 46 West Coast companies.

(Order Report No. 249, The California Personnel Management Assn., 2180 Milvia St., Berkeley, Calif., 17 pages, $1.00)



Plant Engineering

A handbook covering every major area of plant engineering activity, is entirely practical in nature. Its sole purpose is to offer tested solutions to the many daily problems that the plant engineer and his staff encounter. It is not theoretical and is not a textbook.

More than 100 experts in fields related to plant engineering wrote the material for this handbook. Some of these men are top plant engineers reporting detailed solutions to problems met in their own plants. Others are technical specialists in specific fields whose work has proved valuable to plant engineers.

There are 226 detailed studies organized into 13 extensive sections: Sites and Layout, Construction, Housekeeping and Safety, Materials Handling, Maintenance, Paints and Protective Coatings, Mechanical Power and Piping Systems, Electric Power, Lighting, Utilities, Heating, Ventilating and Air Conditioning, Instrumentation and Quality Control, Shopwork. The studies are illustrated with more than 800 halftones and line drawings.

(Plant Engineering Practice, F. W. Dodge Corp., New York, 704 pages, $18.50)

Industrial Relations

In "Outlook for Industrial Relations & Personnel Management," West Coast personnel and industrial relations managers speak up on 12 questions put to them in a business outlook survey made among 201 company personnel executives.

The industrial relations men were asked what problem loomed as their most serious challenge in the year ahead? What employment change is expected? Is the personnel budget adequate? To whom are departmental reports made? Are additional staff services planned this year? What about the union contract? Does the company plan some demands of their own this year? What wage and salary increases look probable? What is being done about office unionization attempts in your company or industry?

The report includes current salary rates paid to top personnel officers, second ranking department managers and first assistants in industrial relations in 46 West Coast companies.

(Order Report No. 249, The California Personnel Management Assn., 2180 Milvia St., Berkeley, Calif., 17 pages, $1.00)

Europe's Need For Oil

Implications and lessons of the Suez crisis are given in this concise and interesting discussion of the background, experience, and future lessons owing to the blocking of the Suez Canal and its impact on the economy of Western Europe. The cumulative effect of the resulting oil shortage on the Organization for European Economic Cooperation nations is discussed. Emphasis is placed on the cooperative program which worked to effect distribution of available supplies to satisfy each participating country's individual fuel needs. Less known but important factors in the success of the OEEC effort, such as the unusually mild winter of 1956-57 and greater availability of hydroelectric power due to the less severe freezeup, are brought out. The book is thoroughly illustrated with charts and tables.

(Europe's Need for Oil, OEEC publications office, 2000 P St., N.W., Washington 6, D.C., 106 pages, 20 pages of statistical annexes, $1.75)

Your
STRUCTURAL STEEL and
STEEL PLATE FABRICATION
ON TIME!

We pride ourselves for "on time" delivery. Thoroughly experienced staff of designers, engineers, and fabricators, to furnish the steel you want, when you want it. AISC members. ASME pressure vessels, tanks, heat exchangers, as well as structural steel. Location served by SP and MP railroads, and our dock is on the Intracoastal Waterway. Write, wire or phone for FACT FILE on our complete facilities.

ST. MARY IRON WORKS, INC.

Steel Fabricators for over Half a Century
FRANKLIN, LOUISIANA PHONE 820

WHEN SPECS CALL FOR...
PROCESS TANKS
custom fabricated on the West Coast

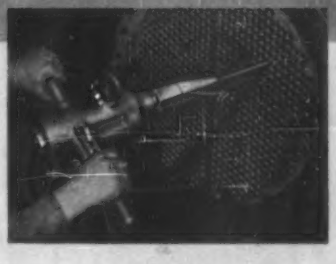
Save on transportation costs, manufacturing time and put yourself in a more competitive position by contacting an experienced "on the spot" source when planning the procurement of process and plant equipment for the West Coast. Send prints for prompt quotation on your next job.

Request Brochure No. K-57

PS F SINCE 1900
PUGET SOUND FABRICATORS, INC.
Craftsmen in Metals
3670 E. Marginal Way • Seattle 4, Wash.
Craftsmen in steel plate and alloys up to 1"

Keep Heat Exchangers on the Line with
WILSON
Maintenance Tools

Heavy-Duty TP-301 Cleaner



Positive air-driven, hollow rotary shaft, drill type tool. Tube is scavenged with air or water while cleaning.

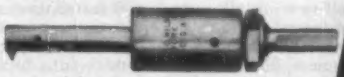
Tube Expanders

Wilson Models 41 and 44 Tube Expanders incorporate an improved, adjustable ball bearing thrust collar and are designed for efficient, easy rolling and maximum roll length adjustment for various tube sheet thicknesses.

Torq-Air-Matic Expander Control

New Wilson Torq-Air-Matic is the first and only air-driven tube expander drive that accurately controls tube expansion by directly measuring torque output at the mandrel.

Tube Cutter



Wilson tube cutter is easy to use and does a fast job. Cutter sizes and shanks available to meet all heat exchanger requirements.

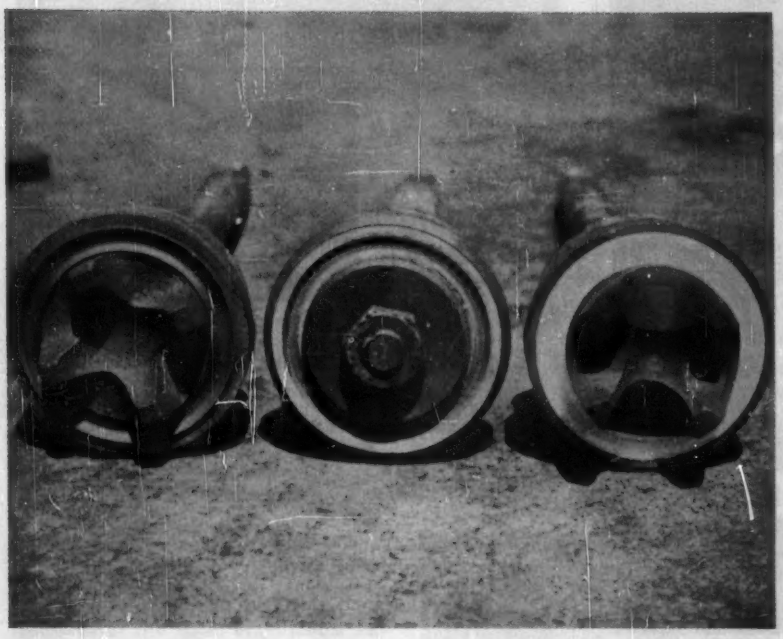
Write today for your copies of Wilson Tube Cleaner catalog No. 77 and Wilson Tube Expander catalog No. 88.

Representatives in principal cities
Thomas C. Wilson, Inc. • 21-11 44th Ave., Long Island City 1, N. Y.
Cable address: "Tubeclean", New York

WILSON
TWS60
TUBE CLEANERS • TUBE EXPANDERS

What's New in Equipment . . .

. . . and Manufacturers Literature



Teflon in Valve Face Doubles Life

Substitution of "Teflon" for lead as the closure face in valves controlling the flow of tetraethyl lead not only has doubled valve life at gasoline blending plants but has sharply reduced maintenance costs and potential exposure to lead hazards.

Tests conducted over the last few years at widely scattered locations have shown such excellent results. The new type valves have been adopted as standard and will be used exclusively in all new installations and replacements at refineries. Packing of "Teflon" has also been substituted for graphite-impregnated woven fiber in the valves because of its chemical inertness and superior lubricating qualities.

Importance of the improvement in valves is pointed up by the fact that faulty valve operation, in the past, has accounted for as much as 25 percent of all operating complaints at TEL blending plants, according to Du Pont statistics. But even more important than the dollar savings is the fact that the new valves, simply by wearing longer and reducing the frequency of repair, considerably reduce possibility of workers' exposure to the hazards of tetraethyl lead.

Most common problem with earlier, lead-faced valves was the fact that the soft lead, while assuring a tight seat in service, was extruded easily by forceful closure of the valve. Moreover, the woven fiber packing used in older type valves tended to dry out, causing difficult operation and requiring periodic tightening of the packing gland to prevent leakage. As a result, the valve often required repacking before the closure disc needed replacement.

Life span of the older type valves varied from two to five years. Equipping valves with Teflon is expected to double their useful life. So far as maintenance is concerned, the company reports that in one test installation at its Carney's Point, N. J., plant, the new type TEL valves were still in satisfactory condition after 60 days of service in a location where the lead-faced valve discs failed in one and a half days due to forceful closure.

Relative wear resistance of valve closure faces of Teflon and commonly used lead are shown in the valve discs above, which were exposed to the same amount of wear in identical systems for handling tetraethyl lead flow in a refinery. Valve facing of Teflon (extreme right) shows virtually no wear, while lead facing in valve at extreme left has been extruded seriously as indicated by concave closure face around perimeter. Valve in center shows comparative wear of trial facing of Teflon impregnated with glass fiber which, while better than lead facing, did not wear nearly as well as Teflon alone. E. I. Du-Pont De Nemours & Co.

Circle E1 green card, last page

Processes For 50 Ammonia Plants In New Bulletin

Bulletin 357 includes flow diagrams for ammonia synthesis from 10 different feedstocks: natural gas, refinery gas, light oils, L.P.G., residual oils, crude oil, hydrogen-rich by-product gas, coke over gas, coal and coke, or water.

Charts include six basic processes for the preparation and purification of gas prior to entering the synthesis loop: high and low pressure catalytic steam reforming, partial oxidation, air steam catalytic reforming, gas producers, low temperature separation, and electrolysis.

Included are all processes used in more than 50 Ammonia Plants which account for an estimated 25 percent of the world's production. Chemical Construction Corp.

Circle E2 green card, last page

Bulletin Gives Criteria For Selecting Flowmeters

Technical Bulletin 91-119, "How to Select Flowmeters", gives criteria for choosing the type of flowmeter to be used in measuring a given fluid or liquid. Advantages and limitations of basic types are listed in chart form. Major manufacturers of various types are also given. Fischer & Porter Co.

Circle E3 green card, last page

Pilot Operated Relief Valve Cuts Tank Breathing

A pilot-operated relief valve for cone roof and other low pressure tanks is said to reduce tank breathing to the minimum —and increase product savings to the maximum—that the pressure and vacuum characteristics of the tank will permit.

These new valves maintain absolute, and automatic, control of tank breathing. They do not open until the pressure setting in the tank reaches the pressure setting of the pilot, or the vacuum in the tank reaches the vacuum setting of the valve. This is unlike conventional valves which start to open at low pressure, so as to build up to full rated flow, within the safe

operating pressure of the tank, thus permitting substantial amounts of vapors—and product—to be vented from the tank—and lost—at less than the tank's safe working pressure. The company reports that records of valves in service, on tanks, prove that these new pilot operated valves pay for themselves in 7 to 8 months by saving the vapors that other valves waste.

As shown in the illustration, the system consists of a valve mounted on a tank, connected through a 3-inch diameter aluminum tube to the pilot, which is also mounted on the tank. Pressure on the tank is applied against the bottom of the pilot valve—and through the tube to the large area on top the resilient membrane—keeping it tightly seated on the valve and preventing any "simmering" and "leakage" at less than set pressure.

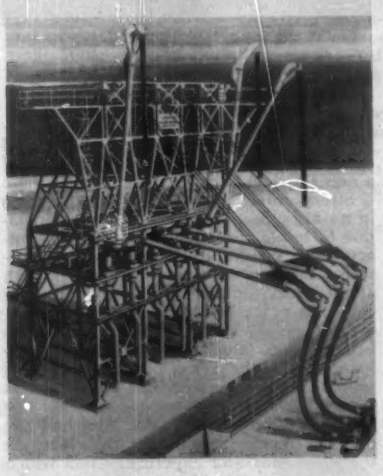
The pilot, being very sensitive, opens full the instant the tank pressure reaches its set pressure, evacuating vapors from the top of the membrane, which opens instantly to full flow position, releasing tank pressure. The pilot closes automatically when the pressure in the tank has been released, reseating the membrane again and shutting off the flow. The Johnston & Jennings Co.

Circle E4 green card, last page

Data Cards Give Weights of Steel Flanges and Fittings

Engineers, estimators and others concerned with the procurement and use of seamless welding fittings and forged steel flanges will be interested in two technical data cards just released. Technical Data Card FDC-251 furnishes approximate weights of the many sizes and types of forged steel flanges, while Technical Data Card FDC-250 supplies the weights of eight different types of welding fittings in a full list of sizes. The Babcock & Wilcox Co.

Circle E5 green card, last page

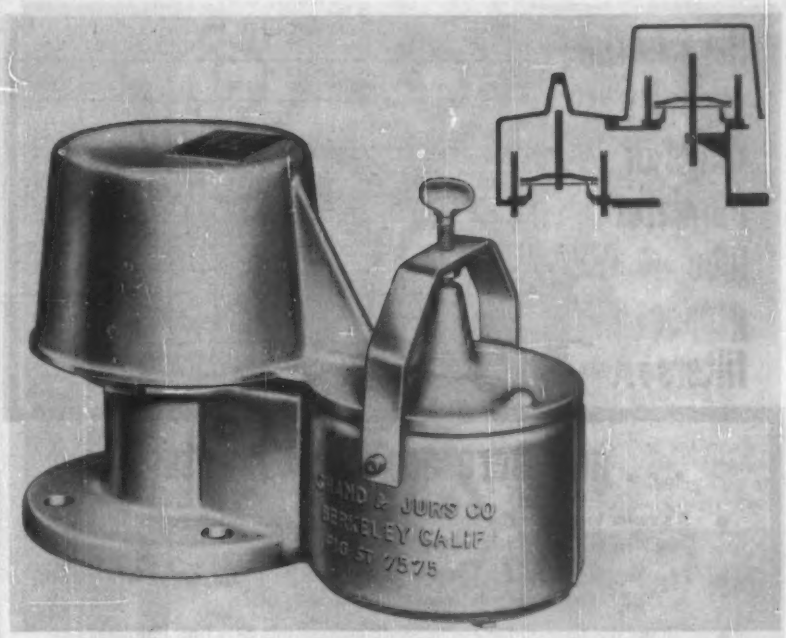


Bunkering Unit Features Six Boom Loading Arms

A six boom unit with four 12-inch booms and two 8-inch booms for bunkering purposes has just been developed.

The unit features push button control which has been placed at ground level in the photograph but which may be centralized in the upper structure. Woodfield Hoist & Associated Industries Ltd.

Circle E6 green card, last page



Small Diaphragm-Type Valve Available

A 3-inch diaphragm-type breather valve has been added to a line of mechanical storage tank fittings. Designated ST-7575, the new small size complements the existing 4-, 6-, 8-, 10- and 12-inch sizes already offered in the this series.

The 3-inch size embodies all the desirable performance characteristics unique in larger sizes of the breather valves. These units feature diaphragm type pallets which maintain an efficient vapor-tight seal at tank pressures and vacuums less than settings.

A patented "balanced-diaphragm action" assures seal against leakage throughout the range of pressures and vacuums in which the breather is designed to remain closed. The simple construction, compact design and rugged durability of the units provide high flow capacities at relatively small pressure or vacuum beyond vent settings. Design is such that a peeling action takes place between the pallet diaphragm and the seat during opening, which helps overcome sticking and freezing.

The 3-inch size's nominal standard setting for either vacuum or pressure is 1.1 inch of water. Valve characteristics: opening at 1.2-inch and closing at 1.0-inch. Shand and Jurs Company.

Circle E7 green card, last page

Radiocarbon Compounds Are AEC License-Exempt

A new service to users of radiochemicals is called EQ Paks. The EQ Paks are qualities of radiocarbon compounds which are AEC license-exempt. They contain 50 microcuries of Carbon-14 compounds. This is the quantity established by the AEC as the maximum Carbon-14 activity that any amount of material may contain without AEC authorization for its sale and possession. Up to 10 such packages may be possessed at one time, but combination of several exempt quantity packages to form an aggregate amount in excess of 50 microcuries is forbidden.

Use of the EQ Pak avoids delays due to licensing procedure and allows immediate progress on new projects. Their high specific activity of 0.5 to 1 millicurie per millimole (approximately 10,000 dps per milligram) permits their use in most tracer experiments.

The compounds are stock items and are shipped via prepaid airmail usually within 24 hours of order receipt. Most of the company's Carbon-14 chemicals are avialable in EQ Paks. Tracerlab, Inc.

Circle E8 green card, last page

Brinell Hardness of 700 On Electrode Deposit

The new Inco-Weld "A" wire brings to the inert-gas welding field all the advantages for welding dissimilar metals which the Incc Rod "A" electrode has made available for metal-arc welding.

Like its companion electrode, the Inco-Weld "A" wire has been designed to produce strong ductile joints in a large number of dissimilar metal combinations. Field tests on 23 such combinations were highly successful and the properties obtained in each case were comparable to those of the weaker member of the joint.

Other features are its excellent operability in all positions, a high-strength and corrosion-resistant deposit, machinability, high impact resistance for sub-zero applications, good elevated-temperature properties, and X-ray quality welds. These properties are further enhanced by the advantages of the inert-gas welding process, which features high deposition rates and good bead contour.

The other new product introduced is the Inco-Hard "1" electrode, a metal-arc welding product for the application of a hard surface overlay to low-alloy steels

For more data on advertised products, use Readers' Service Cards, last page.

Here is the capacity range of Purolator lube grease filters...

CAPACITIES IN GPM
VISCOSITIES IN SSU

ELEMENT SPACING	MICRON EQUIVALENT	WATER 30	100	300	700	1000	3000
.001	25	53	31	18	12	10	6
.0015	37.5	76	44	26	17	14	8
.002	50	97	56	33	21	18	11
.003	75	133	77	46	29	25	14
.005	125	190	110	65	42	36	21
.007	175	194	112	66	43	37	21
.008	200	207	120	71	46	39	23
.010	250	230	133	79	51	44	25
.015	375	230	133	79	51	44	25
.020	500	200	116	68	44	38	21

NOTE: Flow rates are based on clean fluid at 1 PSI initial pressure drop. To approximate the flow of 1 PSI in SCFM for air, nitrogen, or similar gases, multiply the flow in GPM at 100 SSU by 4.

... and here are the advantages:

- It's easier to change the Purolator element between batches. Handles are attached to the specially constructed screw-on case.
- Cleaning the element is fast, easy and thorough; simply rotate the element, manually or mechanically, against a fixed knife blade.
- Filtration is dependable and accurate because this filter uses Purolator's Metal Edge principle, a tight durable coil of precisely spaced metal ribbon.
- The filter is designed specifically for batch filtration of greases.

For more specific information contact Purolator Products, Inc.

Filtration For Every Known Fluid

PUROLATOR
PRODUCTS, INC.
RAHWAY, NEW JERSEY AND TORONTO, ONTARIO, CANADA

TIMELY AND AVAILABLE!

Recently published items in PETROLEUM REFINER have enjoyed such a demand that they have been reprinted as separates and are available at $1.00 each. They are:

- **Fluid Catalyst Design Data,** by F. A. Zenz: An up-to-date orientation and appraisal of recent developments in fundamental studies in fluidization.
- **Disaster Planning,** by Don E. Lambert: Details on how a refinery should prepare for disaster including planning, training, mutual aid, communications and public relations. This Report won an Editorial Award of Merit.
- **Perforated Trays,** by Huang and J. R. Hodson: The most reliable information available for design of perforated trays including handy work sheets to carry out your calculations.
- **Foundation Design of Stacks and Towers,** by V. O. Marshall: Long the standard reference in engineering offices throughout the world, this is a reprint of an article that every design man should keep within easy reach as an effective working tool.
- **Special Note**—We have also located a limited supply of section II of Wayne C. Edmister's **Applications of Thermodynamics to Hydrocarbon Processing** which was originally published in 13 parts in **Petroleum Refiner,** November 1948-December 1949. **Available at $1.00 a copy.**

Send Cash with Order. Address:

REPRINTS, PETROLEUM REFINER

Box 2608, Houston 1, Texas

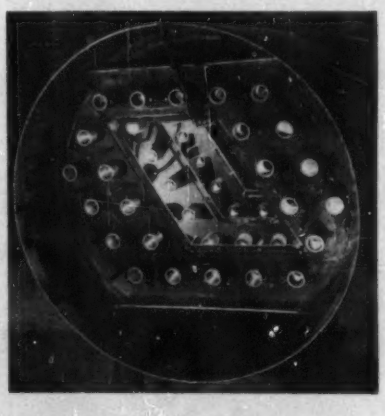
New Equipment...

and cast irons where severe abrasive conditions are present. The deposit from this electrode is structurally similar to Ni-Hard nickel-chromium alloy, and has the same degree of hardness and abrasion resistance. This electrode has smooth arcing characteristics and is operable in all positions. No special techniques regarding weld metal deposition are required.

In other respects, the new electrode is used under conditions typical of hard-surfacing applications, usually requiring that the interbead temperature be held at or below 200 F. and that two layers of hard-surfacing material be applied.

In preliminary field tests on the electrode, the deposit was overlaid on mild steel. Extensive laboratory investigation of this deposit showed a hardness of 650-700 Brinell for the two-layer deposit. A hardness of approximately 500 Brinell was typical of the one-layer deposit. The International Nickel Co., Inc.

Circle E9 green card, last page



All-Bronze Alloy Stops Stress Corrosion Cracking

Victory over a prime metallurgical problem—stress corrosion cracking—is claimed as a result of conclusive field testing of a new Grade-8 alloy.

Stress corrosion cracking often occurs in an alloy because of the atomic segregation of solute elements at the grain boundary. This condition, coupled with a corrosive solution or atmosphere and a high applied or residual stress, eventually caused a grain boundary crack.

In a single phase alloy of aluminum bronze, the aluminum atoms tend to segregate at the grain boundaries during solidification. The corrosive then oxidizes these atoms and their adjacent areas. The high stress breaks the oxide film and the cycle is repeated to eventual failure. In the initial stages of experimentation which consumed 18 months, variations in the processing of the metal did little but extend the period before ultimate failure; it was then that testing turned to the introduction of new elements.

Some 36 different elements were considered suitable for introduction into the alloy in varying minor amounts. Of these, 19 were ruled out after trial disclosed that they adversely affected manufacturing characteristics. Of the 17 remaining, further research and experimentation disclosed that the addition of one-third of 1 percent

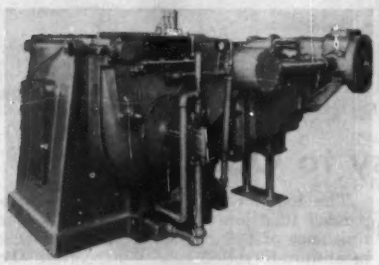
of either tin or silver—not more, not less—produced the modification that eliminated stress corrosion cracking in steam.

In subsequent rigorous testing, both through accredited research institutions and in pilot field installations, Grade-8 proved out on these counts: (1) no stress corrosion failures; (2) safe employment of maximum allowable design stress, and (3) much better weldability than any copper-base alloy known.

(The new material is permitted for use in the construction of ASME approved pressure vessels and can be used up to 500 F. with an allowable working stress of 10,000 P.S.I.)

The sectional view of a fractionating tower shows a variety of parts of Grade-8 alloy, which has been used throughout. Note the internal manways and hold-down studs for bubble caps. Internal welding was with inert-gas shielded-arc process. Ampco Metal, Inc.

Circle E10 green card, last page



Expansion Engine Cools Gases To Minus 300 F.

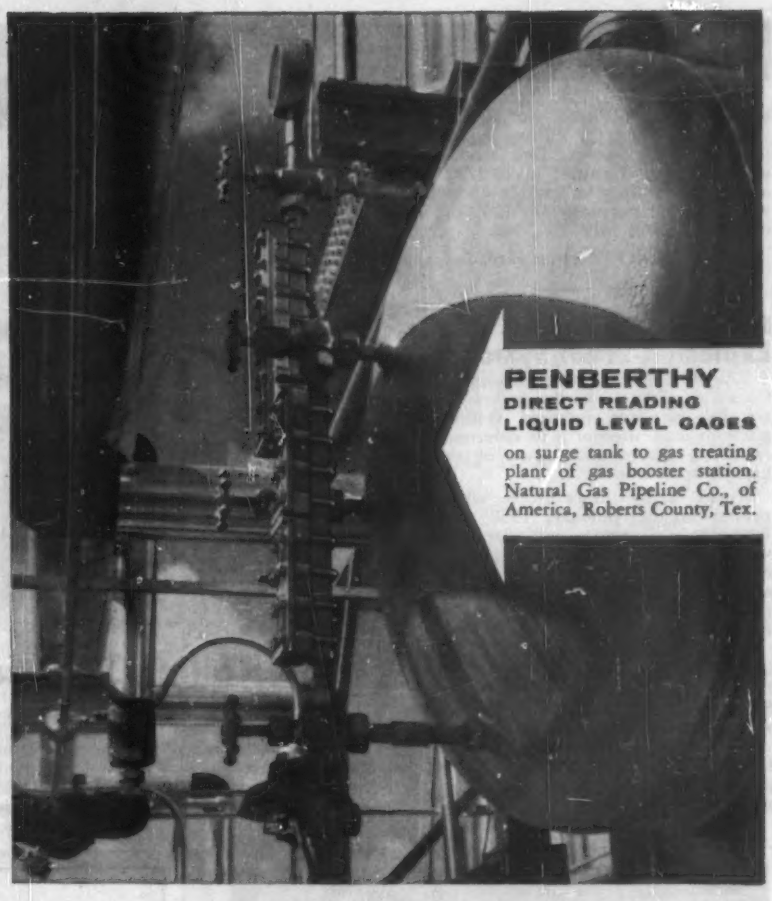
Process demands for cooling gases to temperatures —100 F. and below can be efficiently handled by a new reciprocating expansion engine. Used in conjunction with a low temperature rectifying column, the reciprocating engine, known as the JX Expander, is considered one of the most efficient devices known today for liquefying gases or separating gases by liquefaction. When properly applied, its thermal efficiency is in the order of 75 to 85 percent.

Designed to develop temperatures as low as—300 F, the expansion engine meets many of the needs anticipated in the cryogenic fields, for example the production of liquid oxygen, nitrogen and other gases. The Cooper-Bessemer Corp.

Circle E11 green card, last page

Portable Tool Cuts Sheet Metal or Wire Cloth Easily

A portable Nibbler that will cut woven wire, wire cloth, and gasket up to 3/16-inch can be used as portable tool or mounted



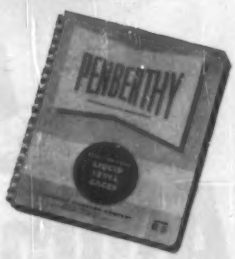
PENBERTHY
DIRECT READING
LIQUID LEVEL GAGES

on surge tank to gas treating plant of gas booster station. Natural Gas Pipeline Co., of America, Roberts County, Tex.

what's so unusual* about
PENBERTHY GAGES?

For over 70 years, Penberthy has been designing and making quality products for the Petroleum industry. We specialize in direct reading liquid level gages and valves. Our gages are available in a variety of materials and special designs. And there is also a complete line of accessories. They will meet all practical requirements for measuring and observing liquids (including corrosive) to pressures of 10,000 psi and temperatures of 750° F. They are the one sure means of obtaining positive, accurate readings.

*Penberthy builds into these gages exclusive extra features which assure you easier and lower cost installation, operation and maintenance. Your investigation and comparison will prove there is *certain satisfaction* in products by Penberthy.



Write for Catalog 36
In this new catalog, the complete line of gages, valves and accessories is described in detail. Technical data and price list are included. Your copy sent on request.

Specials also available.

Everywhere
YOU'RE SEEING MORE PRODUCTS BY
PENBERTHY MANUFACTURING COMPANY
Division of Buffalo-Eclipse Corporation
1242 Holden Avenue Dept. R Detroit 2, Michigan

PENBERTHY

- EJECTORS
- INJECTORS
- CYCLING JET PUMPS
- ELECTRIC SUMP PUMPS
- LIQUID LEVEL GAGES
- GAGE VALVES

For more data on advertised products, use Readers' Service Cards, last page.

New Equipment...

on table. It will also cut sheet metal without distortion by cutting out a continuous ¼-inch strip. Two models are available, one for cutting up to 3/32 wire, and a heavier duty for cutting up to 3/16 wire. The unit operates on 110 volt, AC or DC. Modern Mfg. Co., Inc.

Circle E12 green card, last page

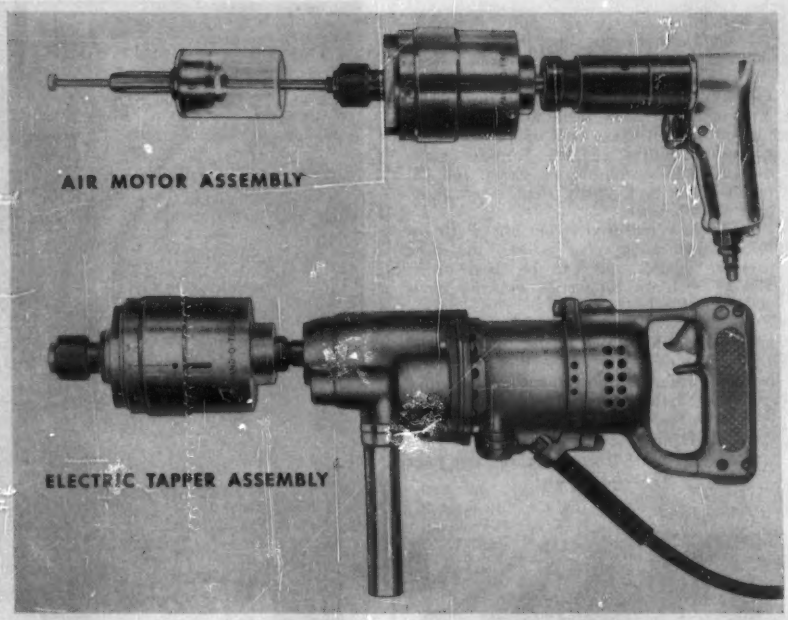
Refiner Reprint On Explosion-Proof Systems

The construction of the Tidewater Oil Co.'s mammoth petroleum processing center in Delaware required considerable planning and ingenuity to determine the existence, degree and extent of this refinery's hazardous areas.

Russell P. Northup's article, which appeared in the January, 1958, issue of PETROLEUM REFINER, indicates how the various areas were classified and then equipped in order to minimize the hazards of explosive, flammable substances being processed or stored throughout the refinery.

As the title and sub-head of the article indicate, classifying hazardous areas is the key to "Explosion-Proof Electrical Systems" and here is how one company went about it and came up with an excellent example of a well-engineered system. We think this article will be of great interest to you. Crouse-Hinds Company.

Circle E13 green card, last page



Tube Rolling Tool Easy to Operate

The Expand-O-Trol is a precision mechanical self-contained torque control unit for controlled tube rolling. The unit is an attractive item because of its low initial cost and its adaptability to your available air or electric tube rolling motors. It is priced to be bought as a maintenance tool.

The tool measures the tightness of expanded tube joints by utilizing the torque resistance of the expanding tube, resulting in uniformly rolled tube joints within the tube bundle. The danger of tube sheet warpage is minimized and the tube joint failure is decreased. Three years of actual

Aluminum Grating

for ramps, walkways, pit covers, floorings, etc.

Patented Upset design provides sure-footed, non-skid, non-directional safety—even in the presence of wet, greasy or other hazardous conditions. Non-magnetic, non-sparking and maintenance-free! Washington Aluminum will fabricate any shape, width or length grating to answer your most exacting requirements. low as **$2.50** per sq. ft.

FREE BOOKLET ON REQUEST.

WASHINGTON ALUMINUM COMPANY, INC.

Dept. 56 • Baltimore 29, Md. • Phone Circle 2-1000

Chemical plant design for more profitable operations

Just Published!

Here are the essential methods for planning and setting up manufacturing operations that function profitably and make the most efficient use of machinery and components. Fully explains waste disposal, structural design, equipment fabrication, design of process equipment *—plus data required to determine if such apparatus is practical and profitable for the plant.*

PLANT DESIGN AND ECONOMICS FOR CHEMICAL ENGINEERS

By MAX S. PETERS, *Registered Professional Engineer*
Associate Professor of Chemical Engineering, University of Illinois

503 pages, 6 x 9, 204 charts, tables, and illustrations, $11.00

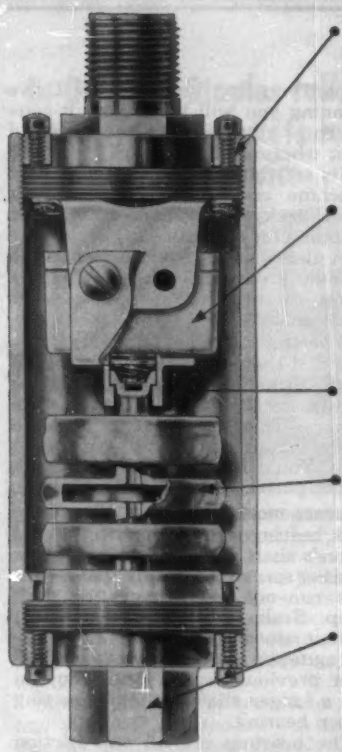
Here are the pitfalls to avoid in selecting the plant location, how to reduce fire and explosion hazards, what constitutes an infringement of patent rights, the best methods for the disposal of toxic materials, how to handle erosion and corrosion in plant equipment, how to estimate the bursting pressure of a thin-walled cylinder, what means can be used to eliminate dirt and scale on heat-transfer surfaces, how to estimate pressure-drop in packed towers, and a host of other techniques for handling the problems of plant equipment design and operation.

You'll see just how to prove if a plant design is profitable and practical, and if its equipment will put the operation on a paying, proficient basis; the 16 important factors affecting plant layout, and how scale models can be put to work for higher plant efficiency—everything you need to know to take full advantage of modern plant methods.

THE GULF PUBLISHING COMPANY

P. O. Box 2608, Houston 1, Texas

NEW PRESSURE SWITCH FOR **HIGHLY CORROSIVE** MEDIA


Threaded (adjustable) Construction Shown; Welded construction optional
Snap action Switch
Overtravel protection
Welded multiple diaphragm sensing element —not to be confused with an accordion bellows.
¼" internal pipe thread pressure connector is standard—Welding fitting optional.

SAVE EXPENSE OF CHEMICAL PROTECTORS...OFTEN MORE THAN THE PRICE OF THE PRESSURE SWITCH

This new tier-tube line of Meletron pressure switches is available in materials suitable for use with concentrated hydrogen peroxide, fuming nitric acid, liquid oxygen, proprietary amine fuels, fluorine, mixtures of fluorine and liquid oxygen and others.

Proof pressures range from 224 to 6000 P.S.I., pressure settings from 2 to 4800 P.S.I. Switches will operate in temperatures from −65° to +275° F. Standard pressure port fitting is ¼" internal pipe thread but may be substituted by special welding fitting. The housing serves as a pressure tight safety capsule in case of a break in the sensing element. Single pole double throw switching elements are rated to 10 amps., for AC and DC circuits. Free leads or Cannon plug are optional for electrical connection. As an added safeguard, the stainless steel models will withstand 2000° heat for five minutes.

Write for bulletins 1110 to 1170.

PRESSURE SWITCH DIVISION

barksdale valves

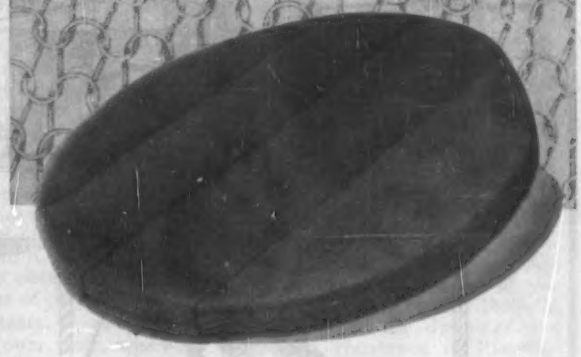
5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

METEX

MIST ELIMINATORS

(ENTRAINMENT SEPARATORS)

Eliminate product loss, cut operating and maintenance ...at low first cost



Metex Mist Eliminators have been used successfully on many applications to knock back liquid entrainment. They are used in any vessel handling liquids and vapors when complete separation of the two phases is desired. Separation efficiency of 99%+ is maintained.

Ask Metex for engineering recommendations. Write today for Bulletin ME-6 and a data sheet.

METEX

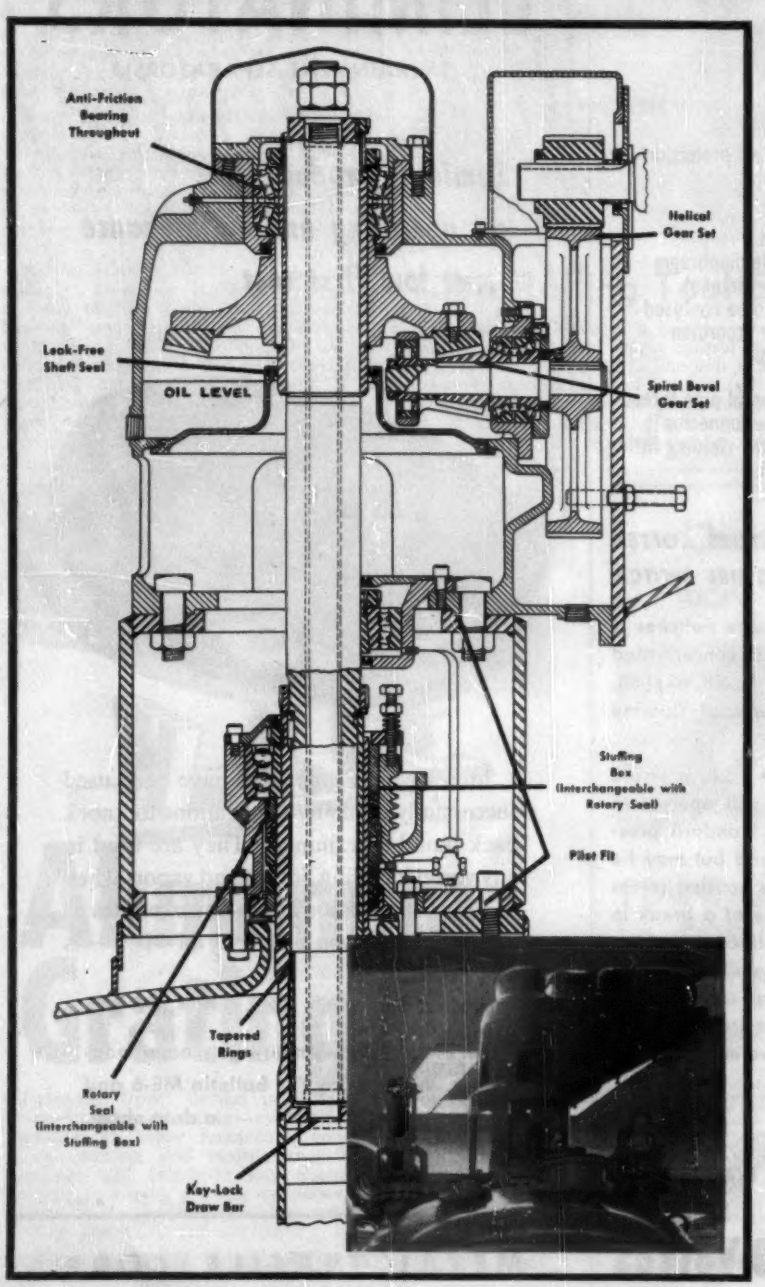
8-107

METAL TEXTILE CORP.

ROSELLE, NEW JERSEY

PFAUDLER

Quietly cut maintenance up to 50% with the new BH Agitation Drive



When you first hear the BH Drive running you will know why it consistently cuts maintenance time and cost wherever it is used.

Its soft hum is the sure sign of a machine constructed to run week after week without once faltering or stopping for repairs.

A glance at its blueprint shows the specific areas where it either *eliminates* or *drastically reduces* your maintenance.

Get perfect alignment in minutes. Notice that the pedestal mount is *keyed* to the drive unit with a pilot fit. The pad mount is *machined* level at the factory. Then the drive is made to fit the mount just one way—the right way. You'd have to work some *not* to get perfect alignment every time.

Squeeze more life from a drive. Only two bearing areas support the BH Drive's shaft. This gives much wider bearing spread. Naturally that means less run-out, less chance of shaft whip. Seals last longer. Alignment is maintained all the time. The critical agitation speed is increased 50% over previous design. And, you can use a longer shaft without inserting a step bearing.

The bearings are all anti-friction types designed in excess of AGMA specifications. Under normal use, they can produce up to 300,000 hours of quiet, wearfree service.

Hardened and lapped spiral bevel gears are *standard*.

Speed up changeovers. You can use either stuffing box or mechanical seal with the BH Drive. Both come as integral assemblies, the Pfaudler-pac, which slip quickly into place. You never remove the drive from its mount to replace a stuffing box or seal.

The new draw bar is key-locked to your agitator. No threads to strip or stick. Tapered rings transmit torque when you draw the bar.

Prevent oil leakage. Besides putting in the usual oil-tight seals, we've recessed the oil reservoir through a well-type construction so that oil level is always *below* the seal. In normal operation oil can never slop over and seep down the shaft.

New motor levelling. Levelling the motor on the BH Drive is easier, too. The new design uses three levelling screws in place of the four jack screws on previous designs.

Three ratings available. You can get the BH Drive rated at 12, 30, or 60 HP at 100 RPM.

For more information on the drive, including complete specifications, send the coupon for our No. 972 Bulletin.

For more data on advertised products, use Readers' Service Cards, last page.

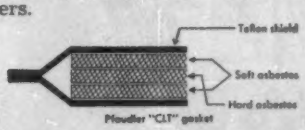
CORROSIONEERING NEWS

B. G. "Joe" Staples talks about Teflon gaskets for corrosive service

Mr. Staples runs our program of Pfaudler Technical Courses for plant maintenance men.

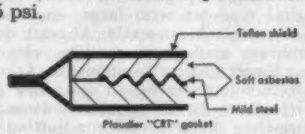
One of his special subjects is "Teflon Gaskets." Thirteen years ago he began devising a gasket for universally corrosion-free service on both glassed-steel and alloy equipment.

Many hundreds of tests later, he and his staff created two separate designs. Both combine Teflon's versatile corrosion resistance with the rigorous physical properties of their fillers.



The Teflon envelope on this design licks the corrosion problem. The center core of hard, compressed sheet asbestos makes it rigid and strong. Thin layers of special soft asbestos let you compress the gasket to get a tight seal without danger to glassed-steel flanges.

This design is for service up to 300° F. and internal pressures to 125 psi.



For temperatures up to 500° F. and pressures to 300 psi, we developed this gasket with a thin corrugated mild steel core. This gives the gasket added strength and a springlike action which helps keep the seal tight and reduces the need for shimming.

FREE BULLETIN. To find out more about Teflon gaskets, send the coupon for Bulletin 502.

Test your corrosives FREE in Pfaudler lab

When you're not quite sure how a corrosive material will affect your glassed-steel or speciality alloy process equipment, send a sample to our laboratory.

A staff of expert corrosioneers will run a series of tests which approximate as closely as possible your actual processing conditions.

These men have run thousands of such tests and recognize quickly the telltale marks of corrosion.

They will report quickly, telling you the best material of construction to use and what use-life you can expect from it. Usually quantitive data are obtained in terms of mils per year of corrosion rates.

Run your own tests. If you prefer to run your own tests, we will gladly supply test equipment and procedures. Then do your own evaluation or return the test equipment to us for observation.

Test materials are all free except for the assembly shown in the picture. They include glassed-steel dumbbells which you suspend directly in your process, glassed-steel cups, or disc assembly shown above.

Full range of materials. Naturally glassed steel is our first interest and is usually the best answer to your corrosion problems. However, we also maintain a line of tantalum, titanium, zirconium, various Hastelloys, and various stainless steels for testing. Other metals and alloys on request.

Send for bulletins. The complete testing procedure and list of materials are contained in Bulletin 919. Bulletin 928 discusses the corrosion resistance of Pfaudler acid-alkali-resistant Glassed Steel. Check the coupon for copies.

PETROLEUM EQUIPMENT by PFAUDLER
a division of **PFAUDLER PERMUTIT INC.,**
Dept. PR-68, ROCHESTER 3, NEW YORK

Please send me ☐ Bulletin 972, BH Series Drive ☐ Bulletin 502, Teflon Gaskets ☐ Bulletin 919 Glassed-Steel and Alloy Samples for Tests ☐ Bulletin 928, The Corrosion Resistance of Pfaudler Glassed Steel.

Name.....

Title.....

Company.....

Address.....

City..... Zone..... State.....

See Chemical Engineering Catalog, pp. 1407-1418 for complete Pfaudler line.

For more data on advertised products, use Readers' Service Cards, last page.

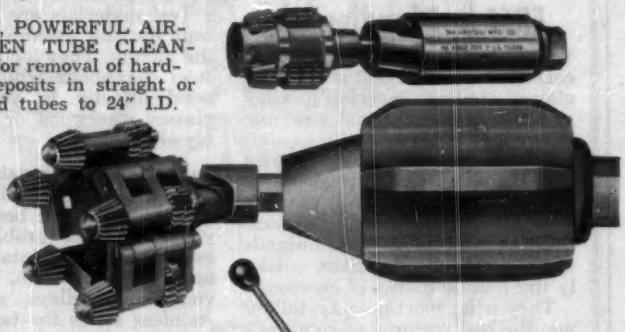
LOWER COSTS
at "turnaround time" with AIRETOOL tube maintenance tools

You'll end up with less down time and lower maintenance costs with Airetool air-driven tube maintenance tools on the job because:

1. **Airetool equipment is fast . . . dependable . . . easy and economical to operate.**
2. **Airetool equipment restores system to maximum efficiency . . . helps to extend tube and equipment life.**

Here are just a few of the many money-saving tools in the AIRETOOL line.

FAST, POWERFUL AIR-DRIVEN TUBE CLEANERS for removal of hardest deposits in straight or curved tubes to 24" I.D.



POSITIVE FEED INTERNAL TUBE CUTTER for quick removal of damaged tubes. Cuts steel or nonferrous tube in sheets to 4" thick. Air or electric driven.

NEW AIRETROL

TUBE EXPANSION CONTROL . . . the answer to fast, easy, accurate tube rolling. Eliminates guesswork . . . over or under expansion. Quick set torque sensing cam stops expansion automatically to .001" accuracy. For tubes ¼" to 1-½" I.D. Send for Airetrol Bulletin #64.

Contact your nearby Airetool representative or write for the complete Airetool Catalog #65 today.

REPRESENTATIVES in principal cities of U.S.A., Canada, Mexico, South America, England, Puerto Rico, Italy, Japan, Hawaii.
EUROPEAN PLANT: Vlaardingen, The Netherlands.
CANADIAN PLANT: 37 Spalding Drive, Brantford, Ontario.

AIRETOOL
MANUFACTURING COMPANY
SPRINGFIELD, OHIO

BRANCH OFFICES: New York, Chicago, Tulsa, Philadelphia, Houston, Baton Rouge.

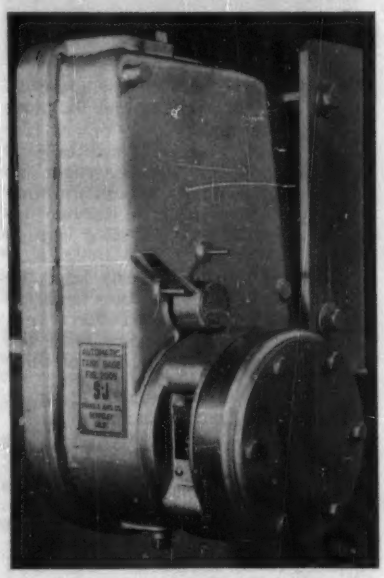
New Equipment . . .

"on-the-job" field tests have proven the tools superiority. Under prolonged use its accuracy remained constant.

The unit consists of few parts, making it practically maintenance free. Through compactness, the size-weight ratio is minimized. Its design incorporates a 'slip-clutch' with a friction wear compensating arrangement. When the desired torque is reached, the special metallic-embedded fiber disc slips against the mating steel hub thus discontinuing further expansion.

Production is stepped up because complete jobs can be rolled to the degree of tightness for which the tool has been set without constant inspection and micrometering. Through its use, inexperienced men can be assigned the job of tube rolling. Only a simple dial setting is needed to increase or decrease torque values, reducing the training time formerly needed. The Gustav Wiedeke Co.

Circle E14 green card, last page



Automatic Tank Gage Has Features Wanted By Gagers

A new automatic tank gage has just been announced. The unit, 2006, has all the important performance advantages most wanted by gagers. Features include: Digital read-out with large, easy-to-read, white on black numerals; Aircraft quality aluminum castings in modern, clean design; Finest quality components; Accurate, uniform tolerances on all machined parts; Efficient, rugged construction—maintenance-free; Faster, easier adjusting procedure; Ready acceptance of transmitter for remote reading systems—no disturbance to pipe or gage reading; Universal mountings for installation on any tank. Shand and Jurs Co.

Circle E15 green card, last page

Service Report Describes Corrosion Inhibitor

Oakite PC 5, the organic, amine type inhibitor designed for injection into the product stream, is described in a service

report telling of its advantages. It can reduce metal replacement costs, reduce downtime, increase throughput, and step up heat exchange efficiency in accumulators, overhead condensers, fractionating towers, feed lines, heat exchangers, and reboilers.

Included in the report are application procedures and data on density, gravity, viscosity, and recommended concentrations. Oakite Products, Inc.

Circle E16 green card, last page

Rigid Polyurethane Pipe Covering Has Low K Factor

Gemfoam K_{17} is an especially modified polyurethane made from a diisocyanate and a polyester resin. This special formulation is precision molded in dimensional standard thicknesses into 36-inch long half sections of rigid pipe covering that will not burn. The unique and inherent qualities of this foam make it the most nearly perfect low temperature insulating material on the market today.

Its name, K_{17}, stands for the unusually low thermal conductivity of 17 at 70 F. mean temperature; lower than any other insulation. This same K factor allows the use of lesser thickness, which in turn gives a savings on sealers, bands and finish material. It also allows a smaller overall heat gain for a given pipe size.

It is formed from a mass of closed cell bubbles, which have entrapped carbon dioxide. This structure gives the material an excellent resistance to water and vapor. Its low permeability puts it in the class of a vapor barrier.

Gemfoam K_{17} is a lightweight rigid foam with high compressive and flexual strength. Its clean, non-irritating, non-toxic qualities make it easy to handle without special tools, while the 36-inch half sections give a labor savings.

The material also has excellent heat and chemical resistance. It can be used for continuous service up to 215 F. and for intermittent or steam out up to 230 F. At 230 F. it still retains 50 percent of its compressive strength. The original strength returns as it cools. It is not affected by gasoline, lube oil or similar materials. Therefore, it can be used in most conditions with the common joint mastics on the market today. Sunlight will discolor the foam to a light brown color, but it does not damage the insulation. Any protective finish will eliminate this discoloration. Texas Foamed Plastics Corp.

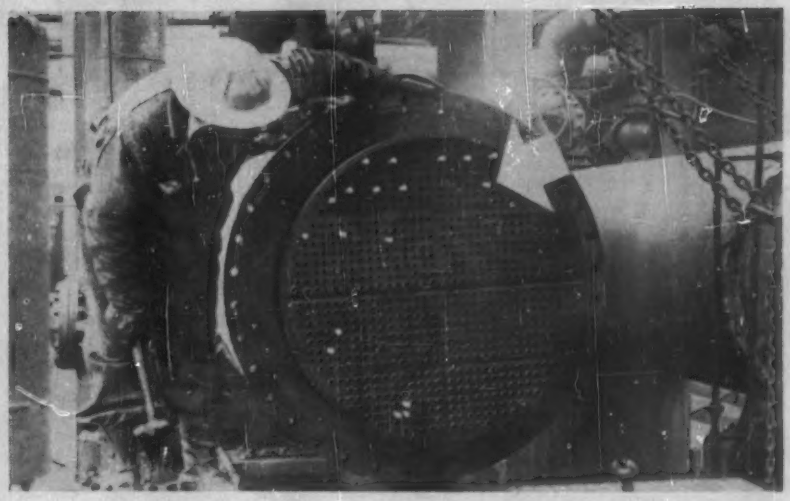
Circle E17 green card, last page

Effect of Radial Loads On Process Pumps Discussed

Radial loads—what causes them, how to measure them, and how their effects on process pumps are controlled, is the subject of a new booklet. Prepared from the original research papers, the booklet "Mechanical Considerations in Pump Design" describes the cause, effect and cure of damaging radial thrust forces on process pump impellers, bearings, wear rings, seals and stuffing boxes, and the shaft itself.

Formulas and diagrammatic explanation of the design and production applications of the findings are clearly and concisely presented. The text covers the basic types of process pumps, and discusses individually the load effects on each. Peerless Pump Division, Food Machinery & Chemical Corp.

Circle E18 green card, last page



Plugs Seal Leaking Exchanger Tubes

Heat exchanger and condenser tube plugs are now being manufactured. They are used to seal off corroded or leaking tubes in a heat exchanger or condenser so that the unit may continue to operate without replacing the entire tube bundle.

One of the most important design features of the tube plugs is a dome-shaped driving surface which insures concentricity in the tube even when struck a glancing blow and virtually eliminates any possibility of damage to the tube sheet. Extensive field tests demonstrate that the dependable performance of the tube plugs under corrosive, high pressure and high temperature conditions is due to their unique design, material and finish.

Their precision-machined taper of 1° 47′ is optimum for sealing the tube and also for preventing damage to either the tube or the tube sheet. The finish is carefully controlled to assure a leak-proof seal at high pressures. Nuclear Products Co.

Circle E19 green card, last page

Radiation Tank Level Gage Cheap As Float Type

Major technological advances have resulted in lowering the costs of the Accu-Ray Tank Level Detector-Controller to make it competitive price-wise with conventional float-level controllers.

A major advantage of the instrument is that no part of it extends into the tank or vessel. It is installed completely outside the tank. Thus it is completely free from fouling by process material and is readily accessible for maintenance. In addition, the instrument can be fail-safe for either the high-level or low-level signal.

The unit can be used in either of two modes of operation: (1) It can be installed so as to provide a relay closure signal when the level rises above or falls below the level of the detector; or (2) It can be installed so that both a high level and a low level signal can be provided from one instrument. Accuracies are available to ± 1/16-inch.

A suitable source of radiation is installed either opposite the detector or across the chord of the tank. The source housing is designed to provide more than adequate shielding so as to reduce the external radiation field well below acceptable tolerances. The radiation field required at the detectors for operation is quite low—only 0.2 mr/hr. Unique circuitry prevents chatter from radiation statistics. Industrial Nucleonics Corp.

Circle E20 green card, last page

Advertisers in This Issue

PETROLEUM REFINER, June, 1958

*The asterisk preceding name of advertiser indicates that detailed data on products and services of the firm will be found in The 1958 Refinery Catalog.

A

*ADSCO Division
Yuba Consolidated Industries, Inc. 44
*Tce Air Preheater Corp. 4
*Airetool Manufacturing Co. 332
Allied Chemical Corp. 37, 77, 113, 272
Alloy Steel Products Co. 317
*Aluminum Company of America 108, 283
*American Brass Co. 233
American Cyanamid Co.
Refinery Chemicals Dept. 60
*American Machine & Metals, Inc. 288
American Meter Co.
Pump Division 306
The Annin Co. 53
Armour & Co. 22-23
Atlas Powder Co. 268-269
Audley Engineering Co. Ltd. 34F
Austin-Western Works
Construction Equipment Division
Baldwin-Lima-Hamilton Corp. 249

B

*The Babcock & Wilcox Co. 95
*Badger Manufacturing Co. 109
*Bailey Meter Co. 117
Baker & Adamson
General Chemical Division
Allied Chemical Corp. 37
Baldwin-Lima-Hamilton Corp. 79, 249
Barber-Colman Co.
Wheelco Division 237
*Barco Manufacturing Co. 300
Barksdale Valves 329a
Bethlehem Steel Co. 311
Betz Laboratories, Inc. 41
*Black, Sivalls & Bryson, Inc. 76
*Blaw-Knox Co. 71
Bonney Forge & Tool Works 246
*Borg-Warner Corp. 273-274
*British Ermeto Corp. Ltd. 34Hb
Bros Incorporated 57
*Buell Engineering Co. 11
*Buffalo-Eclipse Corp. 327
*Byron Jackson Pumps, Inc.
Subsidiary Borg-Warner Corp. 273-274

C

*Camco Products, Inc. 242
*The Cape Asbestos Co. Ltd. 35
*Carrier Corp. 116
Carter-Waters Corp. 319b
*Causeway Reinforcement Ltd. 270
*Chemical Construction Corp. 97
*Chicago Pneumatic 74-75
Chicago Steel Tank Co.
Division U. S. Industries, Inc. 251
*Clark Bros. Co.
One of the Dresser Industries 18-19
Classified Advertising 322
Columbia-Geneva Steel Division
United States Steel Corp. 115
Conoflow Corp. 107
Consolidated Chemical Industries
Division Stauffer Chemical Co. 51
Crane Co. 215
Crane Packing Co. 267
Crouse-Hinds Co. 6

D

Darling Vales & Mfg. Co. 27
The Darlington Insulation Co. Ltd. 34E
Davison Chemical Co.
Division W. R. Grace & Co. 289
*Daystrom Inc. 313a
*Dean Hill Pump Co. 259
Delanium Graphite Division
Kearney Industries 310b
De Laval Steam Turbine Co. 110-111
*Dollinger Corp. 40
The Dow Chemical Co. 223
Dowell 126
*Dresser Industries, Inc. 18-19, 26
E. I. du Pont de Nemours & Co. 122
Durabla Manufacturing Co. 298
*The Duraloy Co. 222
*Durametallic Corp. 314a

E

*E. C. D. Limited 34C
The Eagle-Picher Co. 50
Eastman Chemical Products, Inc. 43
Eddystone Division
Baldwin-Lima-Hamilton Corp. 79
The Electric Controller & Mfg. Co.
Division The Square D Co. 36
Electric Steel Foundry Co. 42
*Elliott Co. 38-39, 224, 309
Engelhard Industries, Inc.
Chemical Division 72
*Enjay Co. 119
Esso Research & Engineering Co. 56
Ethyl Corp. 124-125
Ever-Tite Coupling Co. 265b

F

Farris Engineering Corp. 313b
Felker Bros. Mfg. Co. 54
*Fibreboard Paper Products Corp. 59
*Fischer Governor Co. 266
*Foster Wheeler Corp. 279
The Foxboro Co. 46-47
Frick Co. 314b

G

*The Garlock Packing Co. 31, 232
General Chemical Division
Allied Chemical Corp. 37, 77, 272
General Welding Works, Inc. 265a
Girdler Catalysts
Chemical Products Division
National Cylinder Gas Co. 114
Girdler Construction Division
National Cylinder Gas Co. 114
W. R. Grace & Co. 269
*Graham Manufacturing Co. 280
*Graver Tank & Mfg. Co. 338
*The Griscom-Russell Co. 112
*The Gulf Publishing Co. 34Gb, 319d, 328b
Gunite Concrete & Const. Co. 319a
Gustin-Bacon Manufacturing Co. 220-221

H

*The Harshaw Chemical Co. 258
*Hartzell Propeller Fan Co. 257
*Hendrick Manufacturing Co. 261
*Hills-McCanna Co. 6
Hooker Electrochemical Co. 253
*Hudson Engineering Corp. 10 & 105

I

Independent Engineering Co. 285
*Ingersoll-Rand Co. 213 and 312
The International Nickel Co. 70, 219
*Irving Subway Grating Co. 234a

J

*Johns-Manville Corp. 286-287
The Johnston & Jennings Co. 295

K

Kearney Industries
Delanium Graphite Division 310b
*The M. W. Kellogg Co. 61, 271
The C. M. Kemp Mfg. Co. 291
Kerotest Manufacturing Co. 80
Kieley & Mueller, Inc. 88
*Richard Klinger Ltd. 33
*Koch Engineering Co. 102

L

Lambert Corp. 319C
Layne & Bowler, Inc. 228-229
Lewin-Mathes Co. 58
Limi-Torque Corp. 12
The Lincoln Electric Co. 275
Lukens Steel Co. 302-303
*The Lummus Co. 320-321
The Lunkenheimer Co. 24

M

*The Mack Iron Works Co. 260
Manning & Lewis Engineering Co. 296
Manning, Maxwell & Moore, Inc. 299
The Marley Co. 84
Arthur G. McKee & Co. 247
*Metal Textile Corp. 329b
Metropolitan-Vickers Electrical Co. Ltd. 34D
*Midwest Piping Co. 28
*Mine Safety Appliances Co. 52
Minneapolis-Honeywell 230-231
*Mixing Equipment Co. 85, 120
*Samuel Moore & Co. 294

N

National Aluminate Corp. 262
*National Cylinder Gas Co. 114, 281
National Lead Co. 21
Newalls Insulation Co. Ltd. 34
New England Valve Corp. 250
Newport News Shipbuilding & Drydock Co. 106
Niagara Blower Co. 234b
W. H. Nicholson & Co. 103
*Nooter Corp. 217
*Norton Co. 55

O

*Oakite Products, Inc. 301

P

*Pabco Insulations Division
Fibreboard Paper Products Corp. 59
*Pacific Pumps, Inc. 26
*Peabody Engineering Corp. 292
*Penberthy Manufacturing Co.
Division Buffalo-Eclipse Corp. 327
*Petreco Division
Petrolite Corp. 45
*Petro-Chem Development Co. 264
Petroleum Electric Power Assoc. 96
*Petroleum Refiner 326b
*The Pfaudler Co.
Division Pfaudler Permutit Inc. 330-331
*Phelps Dodge Copper Products Corp. 14-15
Philadelphia Gear Works 12
The Pipe Fabrication Institute 93
Pittsburgh Coke & Chemical Co. 48
The Wm. Powell Co. 64
J. F. Pritchard & Co. of California 297
*Proportioneers, Inc.
Division B-I-F Industries, Inc. 66
Puget Sound Fabricators, Inc. 323b
Purolator Products, Inc. 326a
The Pyle-National Co. 13
The Pyrene Company Ltd. 34B

R

Ready Cool, Inc. 290
Redheugh Iron & Steel Co. Ltd. 34Ha
*The Refinery Catalog 82-83
The Refinery Engineering Co. 92
Reynolds Metals Co. 98-99
W. S. Rockwell Co. 316b
*Rockwell Manufacturing Co. 235, 236
*Rockwood Sprinkler Co. 87, 243, 315
Rome Cable Corp. 8

S

St. Mary Iron Works 323a
*Sarco Co. 276
*Schutte & Koerting Co. 78
*Scovill Manufacturing Co. 307
Sealol Corp. 248
Shand & Jurs Co. 86
Shell Oil Co. 308
Solar Aircraft Co. 29
Solvay Process Division
Allied Chemical Corp. 113
The Square D Co. 36
Stauffer Chemical Co. 51, 101
The Stearns-Roger Mfg. Co. 318
Stone & Webster Engineering Corp. 68-69
*Struthers Wells Corp. 30
*Sun Shipbuilding & Drydock Co. 67
The Swartout Co. 25

T

*Tangyes Limited 34A
*Taylor Instrument Companies 94
Tellepsen Petro-Chem Constructors 17
Tennessee Coal & Iron Division
United States Steel Corp. 115
*The Terry Steam Turbine Co. 90
*Tretolite Co.
Division Petrolite Corp. 32
Truland Chemical Co. 81

U

*Union Asbestos & Rubber Co. 20
U. S. Industries, Inc. 251
United States Gasket Co. 232
*United States Gauge Division
American Machine & Metals, Inc. 288
*United States Rubber Co. 100
United States Steel Corp. 115, 305
United States Steel Export Co. 115
United States Steel Supply Division
United States Steel Corp. 115
*The United States Stoneware Co. 73
Universal Oil Products Co. 62-63, 245

V

*Henry Vogt Machine Co. 91
Vokes Genspring Ltd. 34Ga
*J. H. H. Voss Co. 316a

W

Warren Petroleum Corp. 238
Washington Aluminum Co. 328a
Wedgeplug Valve Co. 65
Western Supply Co. 49
*Weston Instruments
Division Daystrom Inc. 313a
Wheelco Division
Barber-Colman Co. 237
*Thomas C. Wilson, Inc. 89, 323C
Wisconsin Protective Coating Co. 118
Worcester Valve Co. 277
*Worthington Corp. 253-256
Wright Chemical Corp. 278
Wyatt Metal & Boiler Works 337

Y

*Yarnall-Waring Co. 2
*Yuba Consolidated Industries, Inc. 44, 284

Z

*John Zink Co. 310a

use these

Reader's Service Cards for More Information

Circle code number for more data on "New Equipment" editorial items

Circle page number for more information on ADVERTISED products

Quick—Easy

Use these cards to get quick information about New Equipment, Catalogs and literature mentioned in the Editorial columns or advertised in PR

PETROLEUM REFINER Readers' Service Card — June, 1958 Issue*

EDITORIAL ITEMS—Circle code numbers on which more information desired:

E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
E11	E12	E13	E14	E15	E16	E17	E18	E19	E20

ADVERTISEMENTS—Circle page number of ad for more products information:

2	4	6	8	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
27	28	29	30	31	32	33	34	34A	34B	34C	34D	34E	34F	34Ga	34Gb	34Ha	34Hb	35	36
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
97	98	99	100	101	[illegible]	103	104	105	106	107	108	109	110	111	112	113	114	115	116
117	119	120	122	124	213	215	217	219	220	221	222	223	224	226	228	229	230	231	232
233	234a	234b	235	236	237	238	242	243	245	246	247	248	249	250	251	253	254	255	256
257	258	259	260	261	262	264	265	266	267	268	269	270	271	272	273	274	275	276	277
278	279	280	281	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298
299	300	301	302	303	305	306	307	308	309	310a	310b	311	312	313a	313b	314a	314b	315	316a
316b	317	318	319a	319b	319c	319d	320	321	323a	323b	323c	326a	326b	327	326a	328b	329a	329b	330
331	337	338																	

Name (Please Print)_____

Company_____ Position_____

Address_____

*JUNE ISSUE CARD EXPIRES SEPTEMBER 15, 1958 — Check Square for Extra Card ☐

Postage Will be Paid by Gulf Publishing Company

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD

First Class Permit No. 7 (Sec. 34.9, P. L. & R.), Houston, Texas

Petroleum Refiner

BOX 2608

HOUSTON 1, TEXAS U.S.A.

"GREATEST CONTRIBUTION" Nominee

I nominate_____

for a listing in PETROLEUM REFINER'S Honor Pages to be presented in its Oil Centennial Edition, January 1959 as being the man who has made the greatest contribution to the Oil, Gas and Petrochemical Processing Industry.

(Signed)_____

(Address)_____

(Tear out card and mail after writing in your nomination. If you wish to elaborate, please use an envelope with supporting facts attached to the card.)

Who's Your Man?

(see Page 216)

use these

Reader's Service Cards for More Information

Postage Will be Paid by Gulf Publishing Company

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD

First Class Permit No. 7 (Sec. 34.9, P. L. & R.), Houston, Texas

Petroleum
Refiner

BOX 2608

HOUSTON 1, TEXAS U.S.A.

PETROLEUM REFINER Readers' Service Card — June, 1958, Issue*

EDITORIAL ITEMS—Circle code numbers on which more information desired:

E1 E11	E2 E12	E3 E13	E4 E14	E5 E15	E6 E16	E7 E17	E8 E18	E9 E19	E10 E20

ADVERTISEMENTS—Circle page number of ad for more products information:

2	4	6	8	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
27	28	29	30	31	32	33	34	34A	34B	34C	34D	34E	34F	34Ga	34Gb	34Ha	34Hb	35	36
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116
117	119	120	122	124	213	215	217	219	220	221	222	223	224	226	228	229	230	231	232
233	234a	234b	235	236	237	238	242	243	245	246	247	248	249	250	251	253	254	255	256
257	258	259	260	261	262	264	265	266	267	268	269	270	271	272	273	274	275	276	277
278	279	280	281	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298
299	300	301	302	303	305	306	307	308	309	310a	310b	311	312	313a	313b	314a	314b	315	316a
316b	317	318	319a	319b	319c	319d	320	321	323a	323b	323c	326a	326b	327	328a	328b	329a	329b	330
331	337	338																	

Name (Please Print)_____

Company_____ Position_____

Address_____

*JUNE ISSUE CARD EXPIRES SEPTEMBER 15, 1958 — Check Square for Extra Card ☐

Postage Will be Paid by Gulf Publishing Company

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD

First Class Permit No. 7 (Sec. 34.9, P. L. & R.), Houston, Texas

PETROLEUM REFINER

BOX 2608

HOUSTON 1, TEXAS U.S.A.

Quick–Easy

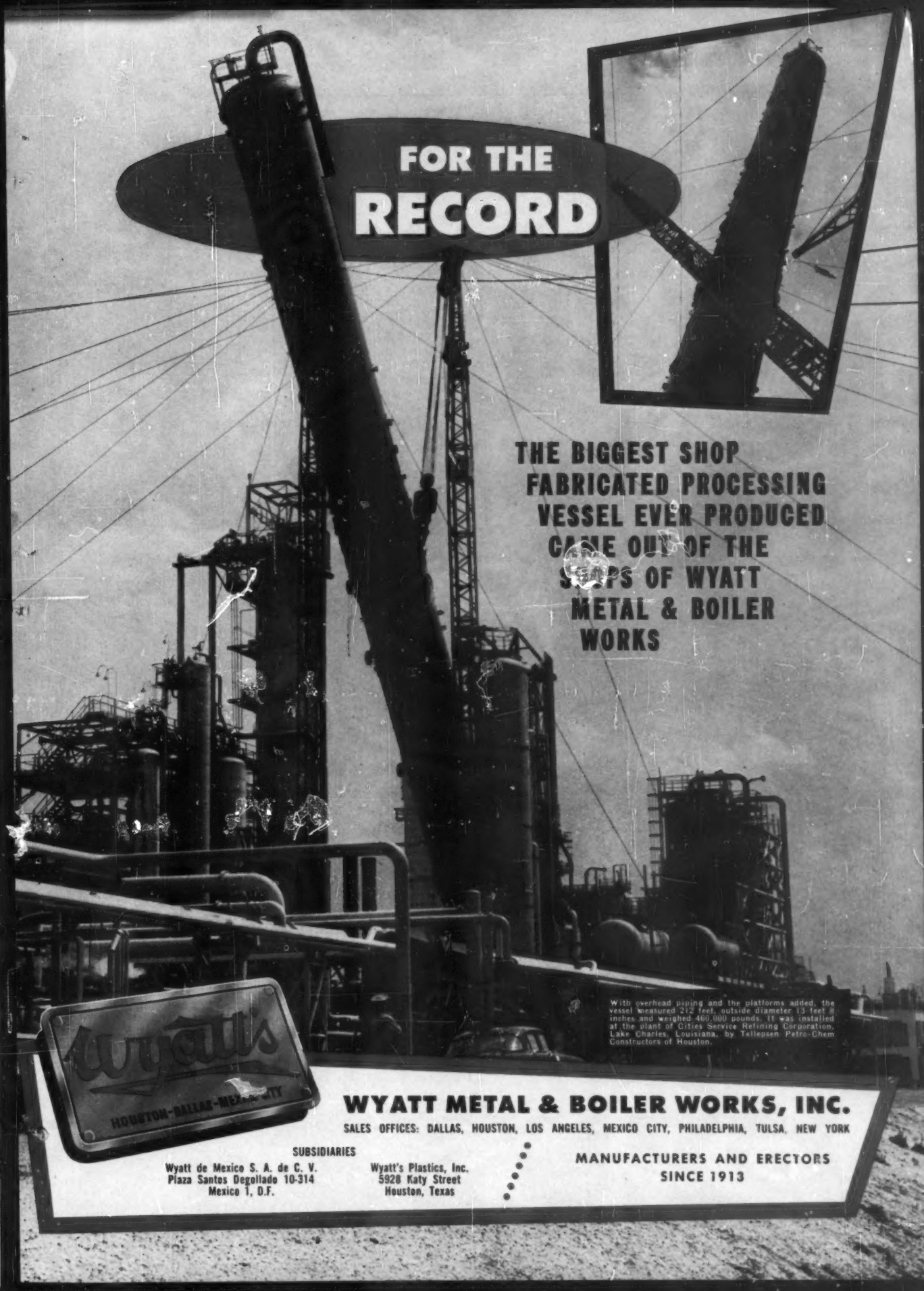
Use these cards to get quick information about New Equipment, Catalogs and literature mentioned in the Editorial columns or advertised in PR

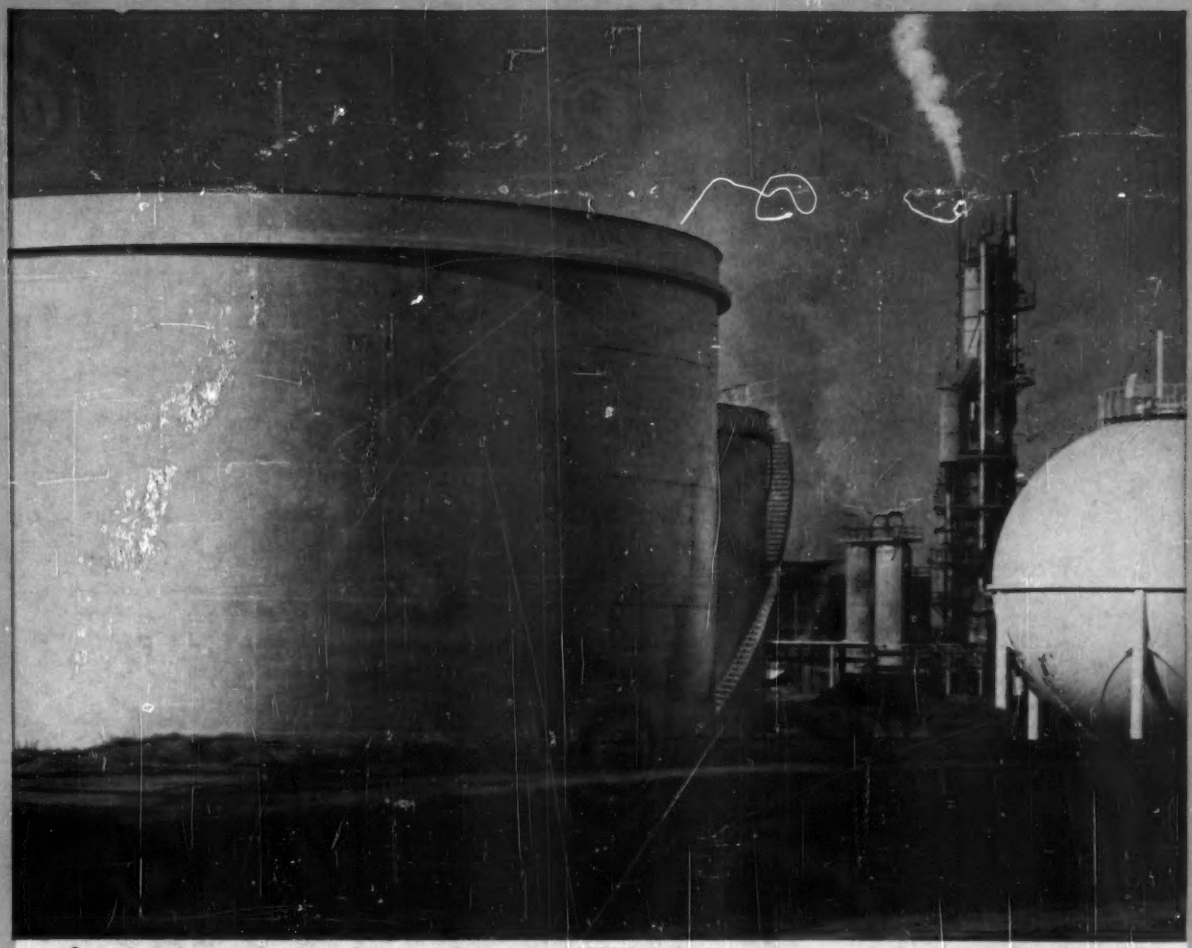
Circle code number for more data on "New Equipment" editorial items

Circle page number for more information on ADVERTISED products

Nominate Your Man

(Use this card after reading the bottom of Page 216 in this issue)


FOR THE
RECORD
THE BIGGEST SHOP
FABRICATED PROCESSING
VESSEL EVER PRODUCED
CAME OUT OF THE
SHOPS OF WYATT
METAL & BOILER
WORKS
With overhead piping and the platforms added, the vessel measured 212 feet, outside diameter 13 feet 8 inches and weighed 460,000 pounds. It was installed at the plant of Cities Service Refining Corporation, Lake Charles, Louisiana, by Tellepsen Petro-Chem Constructors of Houston.
Wyatts
HOUSTON-DALLAS-MEXICO CITY
WYATT METAL & BOILER WORKS, INC.
SALES OFFICES: DALLAS, HOUSTON, LOS ANGELES, MEXICO CITY, PHILADELPHIA, TULSA, NEW YORK
SUBSIDIARIES
Wyatt de Mexico S. A. de C. V.
Plaza Santos Degollado 10-314
Mexico 1, D.F.
Wyatt's Plastics, Inc.
5928 Katy Street
Houston, Texas
MANUFACTURERS AND ERECTORS
SINCE 1913



Graver's assignment for this refinery included seven double-deck floaters, eleven cone roofs and one Graversphere®.

The Key to Low Vapor Losses When Throughput Is High...

Minimizing vapor losses, particularly when daily throughput is high, can substantially increase refinery profits.

Prominent in the refinery above are seven modern Graver Double-Deck Floating Roof Tanks, long proved most effective with Graver's Vapor-Stop Seal in controlling vapors. The double-deck design eliminates standing losses and minimizes filling losses. In hot sunshine, the double deck offers important insulating advantages. In heavy rain or snow, the double deck provides additional buoyancy and stability for the roof. Drainage is positive—to a sump in the center.

When you figure Graver Double-Deck Floating Roof Tanks for your product storage, you are assured of the most efficient tank of this design that you can buy. May we prove this?

GRAVER

Building for the Future on a Century of Craftsmanship in Steels and Alloys

GRAVER TANK & MFG. CO., INC.

EAST CHICAGO, INDIANA • New York • Philadelphia
Edge Moor, Delaware • Pittsburgh • Atlanta • Detroit • Chicago
Tulsa • Sand Springs, Oklahoma • Houston • New Orleans
Los Angeles • Fontana, California • San Francisco